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CONTENTS.

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FRIDAY, NOVEMBER 26, 1920.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

ONE-HUNDRED-AND-SIXTY-SEVENTH SESSION, 1920-1921.

NOTICES.

NEXT WEEK.

MONDAY, NOVEMBER 29TH, at 8 p.m. (Cantor Lecture). A. CHASTON CHAPMAN, F.R.S., F.I.C., "Micro-Organisms and some of their Industrial Uses." (Lecture I.)

WEDNESDAY, DECEMBER 1ST, at 8 p.m. (Ordinary Meeting.) MISS LOUISA F. PESEL, President of the Guild of Embroideresses, "Embroidery: National Taste in relation to Trade." SIR CECIL HARCOURT SMITH, C.V.O., LL.D., Director and Secretary, Victoria and Albert Museum, in the Chair.

Further particulars of the Society's Meetings will be found at the end of this number.

FIRST ORDINARY MEETING.

Wednesday, November 17th, 1920; ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council and Treasurer, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Ainscough, Thomas M., O.B.E., Calcutta, India.
Alexander, W., London.
Arathoon, Hoseb Sarkies, London.
Atkins, Rev. Alfred Cuthbert, Berks.
Bailey, Charles F., Newport News, Virginia, U.S.A.
Barber, Richard, London.
Barnard, James Tebbutt, London.
Baumann, F. W., New Jersey, U.S.A.
Betts, Horace Richard, Southwell, Notts.
Bogra, Hon. Nawab Altaf Ali (of), Bogra, Bengal, India.
Buckley, James Francis, Buckhurst Hill, Essex.

Bown, Eric Inston, Leigh-on-Sea, Essex.
Cameron, Alexander, M.Inst.C.E., Bombay, India.
Carson, Rev. James, Cowper, New South Wales, Australia.
Casey, Richard Gardiner, Melbourne, Australia.
Chettle, Charles F., London.
Chetty, Hon. Rao Sahib M. Ct., Muthiah, Madras, India.
Chittick, James, New York City, U.S.A.
Clapperton, George, Atherton, Nr. Manchester.
Clegg, Mrs. Florence Maria, Ballarat, Victoria, Australia.
Colabawala, J. R., Morar, Gwalior, Central India.
Cordingley, Herbert, Pudsey, Leeds.
Cowper, Rev. H. V. de Aranjo, Halifax, Yorks.
Currie, General Sir Arthur William, G.C.M.G., K.C.B., Montreal, Canada.
Dalton, Rev. Canon J. N., K.C.V.O., C.M.G., LL.D., Windsor Castle.
Darbhanga, His Highness the Maharajadhiraja of (Sir Rameshwar Singh Bahadur, G.I.C.E.) Simla, India.
Dealey, Professor James Quayle, A.M., Ph.D., Providence, Rhode Island, U.S.A.
Delprat, Guillaume Daniel, C.B.E., Melbourne, Australia.
Einzig, Paul, London.
Emley, Frank, F.R.I.B.A., Johannesburg, South Africa.
Enderlein, F. O., New Barnet, Herts.
Farmer, William, Canton, China.
Fellows, Douglas Vincent Letchfield, London.
Fransella, Albert Jan, London.
Frost, William, J.P., Macclesfield.
Greer, Albert Alexander, Athabasca, Canada.
Hadley, Harry Edwin, Kidderminster.
Halliday, James Herbert, Shipley, Yorks.
Hammond, John, Sheffield.
Handover, Will P., Negri, Sembilan, Federated Malay States.
Harnden, Charles Arthur, Alderley Edge, Cheshire.
Heath, Gilbert Octavius, Yokohama, Japan.
Hebbert, Captain Perceival Benbow, Manipur, India.
Henderson, James, Scawby, Lincolnshire.
Henn, J. H. E., Manchester.
Hill, W. Matthews, London.
Hogg, James Sneddon, M.Inst.M.E., Calcutta, India.
Huang Yen-Pei, Litt. D., Shanghai, China.
Hulton, Sir Edward, Bt., London.
Imam, S. Haider, M.R.A.S., Moradpur, Patna, India.
Ivatts, Harold E., London.
Jallan, Soorajmull, Calcutta, India.
Joseph, George Frederick, London.
Jorstad, Arne N., London.
Kearton, Harold Percival, Southport.
Kibe, Rao Bahadur Sardar M.V., M.A., Holkar State, Indore, Central India.
Knapman, William Walter James, Westcliff-on-Sea, Essex.
Knight, Major-General Sir Wyndham, K.C.I.E., C.B., C.S.I., D.S.O., Poona, India.
Le Bas, Edward, London.
Lieu, D. K., Peking, China.
Limbrey, George Henry, Barnet, Herts.
Lohmann, A. William, Tacoma, Washington, U.S.A.
Lumb, Wilfred, M.Inst.P.T., London.
McConnel, Colonel Frederic Robert, Buxton.
McCulloch, John Exley, London.
MacDonald, A. E., London.
McElwain, Major James, Shorncliffe, Kent.
Manger, Herbert A., London.
Marriott, T. Bruce, F.I.C., M.I.M.M., London.
Meriwether, Charles N., Kentucky, U.S.A.
Mitchell, Frederick J., Nova Scotia, Canada.
Morshead, Major H. T., R.E., Dehra Dun, India
Morton, John J., M.D., Texas, U.S.A.
Nagersheth, Oomabhai Manibhai, London.
Nathan, Sir Robert, K.C.S.I., C.I.E., London.
Nawanagar, Lieut.-Colonel His Highness the Maharaja Jam Saheb of, G.B.E., K.C.S.I., London.
Nunn, William, Bangkok, Siam.
Noott, Lieut.-Colonel C. C., C.M.G., D.S.O., London.
O'Brien, J. S., Nova Scotia, Canada.
Parsons, E. A., Epsom, Surrey.
Parsons, S. R., Toronto, Canada.
Peacock, Alfred Leopold, Carlisle.
Perree, Walter Francis, C.I.E., Dehra Dun, India.
Pickstone, Cornelius, J.P., Radcliffe, Lancashire.
Pooley, Henry Jeffries, London.
Queeny, John Francis, St. Louis, Missourie, U.S.A.
Quinn, J., F.A.A., London.
Raha, Rai Bahadur Sarat Kumar, Calcutta, India.
Robinson, John, J.P., Bradford.
Ryan, George Michael, F.L.S., London.
Ryan, Thomas, C.I.E., Simla, India.
Seth, George G., Singapore, Straits Settlements.
Shaw, William Robert Douglas, London.
Singh, Pratap, B.Sc., Morar, Gwalior, India.
Southwell, Bailey, Johannesburg, South Africa.
Stevens, Cyril, A.C.A., F.L.A.A., London.
Stevenson, William Andrew Gray, London.
Stoll, Sir Oswald, London.
Taylor, Harry Wilfred Dick Colebrook, Calcutta, India.
Tewary, Pyare Lal, Sarila State, Central India.
Theakston, Francis, O.B.E., London.
Thom, John Herbert, Paisley.
Thomas, A., J.P., West Maitland, New South Wales, Australia.
Varma, Professor S. P., M.A., Jubbulpore, India.
Wallis, Edward, London.
Wheatley, Henry Lawrence, Assoc. M.Inst.C.E., Rio de Janeiro, Brazil, South America
Wheeler, Adrian Charles Stewart, London.
White, John Francis, Bradford, Yorks.
Wilson, Lieut.-Colonel Sir Arnold Talbot, K.C.I.E., C.S.I., C.M.G., D.S.O., London.
Williams, S. C., M.A., Calcutta, India.
Wright, Frank, Bolton.
Yusuf-Quraeshi, S. M., Baghdad.

The Chairman presented the Society's medals awarded for papers read during the last session :—

At the Ordinary Meetings :—

JOHN WESTALL PEARSON, "The Seed Crushing Industry."

SIDNEY PRESTON, C.I.E., "English Canals and Inland Waterways."

SIR JAMES CURRIE, K.B.E., C.M.G., "Industrial Training."

AIR-COMMODORE EDWARD MAITLAND, C.M.G., D.S.O., A.F.C., "The Commercial Future of Airships."

In the Indian Section :—

SIR WILLIAM STEVENSON MEYER, G.C.I.E., K.C.S.I., "The Indian Currency System and its Developments."

ALBERT HOWARD, C.I.E., M.A., F.L.S., "The Improvement of Crop Production in India."

In the Colonial Section :—

SIR FRANCIS WATTS, K.C.M.G., D.Sc., "Tropical Departments of Agriculture, with special reference to the West Indies."

At a Joint Meeting of the Indian and Colonial Sections :—

SIR JOHN CADMAN, K.C.M.G., D.Sc., "The Oil Resources of the British Empire."

The Chairman's address will be published in the next issue of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, OCTOBER 15th, 1920.

SIR CHARLES C. MCLEOD in the Chair.

BRITISH TRADE WITH INDIA.

By THOMAS M. AINSCOUGH, O.B.E.,

H.M. Senior Trade Commissioner in India and Ceylon.

The subject of my paper this afternoon is an unusually wide and many-sided one, and I fear that it would be impossible adequately to deal with every facet of it in the short space of time available. It was decided, however, to retain the comprehensive title, as some of the eminent authorities whom I feel honoured to see here to-day may in the ensuing discussion, wish to give you the benefit of their great experience and prefer to deal with certain other aspects of the question than those which I am about to treat. My primary object to-day is to consider India as the greatest market for British goods ; that is, to approach the subject rather from the angle of vision of the British exporter than from that of the industrialist or merchant in India. I do this advisedly : firstly, because this is the principal standpoint from which my activities in India are directed, and I am, therefore, better qualified to speak of those matters, which have formed the subject of close study for the past three years ; and, secondly, because I think this aspect of the subject has, to some extent, been overlooked during recent years, and particularly during the present industrial renaissance in India. I propose, therefore, as briefly and concisely as possible, to outline the position of our trade in India at the outbreak of war ; to trace the far-reaching changes which have been brought about by the War ; to examine the sources of our strength, and also of our weakness ; to make some suggestions for the future ; and, in conclusion, to say a few words with regard to the present difficult situation.

At the outbreak of war in 1914, the position of the United Kingdom, as the principal supplier of India's requirements of manufactured goods was practically unchallenged. In the pre-war quinquennium seventy per cent. of the total imports into India were drawn from the British Empire, and 63 per cent. from the United Kingdom, while the balance of 30 per cent. was largely made up of commodities, such as sugar, mineral oil and certain types of Oriental produce, which cannot be considered to be directly competitive. The year 1913 indicated the high-water mark of British shipments to India. In that year, a total of £78,000,000 worth of British goods were imported, of which no less than 96 per cent. represented manufactured articles. India was then, and I am glad to say still remains, the most important market in the world for British manufactured goods. It is obvious, therefore, that the prosperity of the country and the maintenance of the purchasing power of the Indian people, is of the most vital importance to the industries of the United Kingdom.

I have said that British goods were virtually unchallenged in India prior to the War. Mention should be made, however, of German and Austrian trade, which was considerable and increasing, but which largely consisted of a wide variety of cheap and meretricious articles for the bazaar demand, which did not directly compete,

as their quality was often below the standard which the United Kingdom makers cared to produce. The volume of German and Austrian trade with India was only one-seventh of that from the United Kingdom, but there was some fear that, having gained a footing in the bazaars with the cheaper goods, increased competition would later be experienced in the staple articles of import. During the War, it has been possible to investigate the position of the German merchants in India, and it has been shown that in many cases they relied upon the profits which they made in their monopolies of the hides and dyestuffs trades, to obtain a footing in the miscellaneous import business. Very great risks were taken for a totally inadequate remuneration, and this had already resulted in serious financial embarrassment in one or two instances. On the whole, I believe that the German and Austrian import houses in India were doing business on conditions, and for a remuneration, which would have been held to be unsound and inadequate by any British firm of similar standing, and I do not think our trade would have been seriously affected, even if the War had not taken place.

The foundations of our pre-war predominance in trade with India were solid and well laid, and represented the outcome of years of enterprise, sound trading, and integrity on the part of manufacturers, exporters and distributors, both in this country and in India.

In the first place, the greatest demand has always been for those types of manufactured goods in which this country stood pre-eminent. An analysis of the exports of British manufactures in India in 1913, shows that the trade may readily be divided under three main and distinct headings: firstly, textiles, amounting to the enormous total of £40,000,000, or 60 per cent. of the whole; secondly, metals and machinery, amounting to £17,000,000, or 25 per cent. of the total, and, lastly, various railway and mill stores, together with the miscellaneous hardware, soft goods and sundries which make up what is known as the bazaar trade. This last item accounted for £10,000,000, or 15 per cent. of the total exports.

In textiles, Lancashire has always been in a position to meet fair competition from any part of the world, whether on the score of quality or price, and the marketing organisation employed in India by the cotton trade was, and is, admirably suited to the needs of the country. The output of the Indian mills met the demands for the coarser yarns and fabrics, but the range of cloths in which they competed was not a wide one, although, even in 1913, the tendencies towards finer spinning and extensions in looms were already being felt. As regards metals, machinery, and railway and mill supplies, British makers were in a strong position, owing to the fact that the public works and railways of India were developed on British standards and practice, and the industries of the country were largely managed by British and Indian industrialists on home models and with the aid of managers and foremen who had received their training and experience in British mills and works. The most effective competition was met with in the thousand-and-one miscellaneous articles comprising the bazaar trade. In this section low price and a showy exterior counted for more than quality and durability, and our German and Austrian rivals by their careful study of the details of the trade, and also by reason of the long credits given, were able to beat us in a good many lines.

Perhaps the next most important factor in our pre-war economic position in India was the admirable and complex distributing organisation which has been built up by generations of British merchants. The decline of the East India Company synchronised with the foundation of those great merchant houses of first-class standing through whose hands the whole of the trade formerly passed, and to whose foresight, energy and strict integrity the soundness of our position is largely due. In the past the distribution of British goods overseas has been almost entirely effected by merchants, thus enabling the home manufacturer to devote his whole energies and resources to production. The result has been that our merchant organisation throughout the East, and particularly in India, was unique and had no parallel in the case of any competing country. However much we may sometimes be inclined in these days of changing conditions to criticise the attitude of the merchant importers in India it should always be remembered that they were responsible for the development of our trade to its pre-war position of eminence, and deserve

very great credit. Their activities have been facilitated by the great Eastern exchange banks, on whom has fallen the burden of financing the trade through the periods of depression and difficulty which occur with such regularity in Eastern markets. Mention should also be made of the admirable transport arrangements between the United Kingdom and India. The cargo-carrying lines of steamers on the Indian run provide one of the most frequent regular and efficient services in the world and are not equalled by any of our competitors.

A further great asset to the British manufacturer and exporter has been the centralising in London of a very large share of the purchases for India. For example, the requirements of the Public Works Department and the State-worked railways were bought through the medium of India Office Stores Department. The Indian railway companies obtained their plant and stores from their London offices. The firms of managing agents controlling Indian industries relied on their London houses for the supplies of machinery and equipment, while every importing firm of standing in India passed on its indents either to its own office or to a purchasing agent in London or elsewhere in the United Kingdom. The result has been that the British manufacturer has been brought into personal contact with the purchaser and has usually obtained cash against documents in London. Foreign competition was largely excluded, and the buyers for India have been in close touch with the latest industrial developments in this country. British manufacturers, therefore, particularly of iron, steel, railway plant and industrial stores, were relieved of the necessity of setting up costly branches in India, and so long as foreign competition was not evident, the system, from their point of view, was a most satisfactory one.

Finally, notwithstanding a great deal of loose criticism of the British exporter, which has always been very prevalent in overseas markets, and which is largely due to the ingrained British habit of self-depreciation, the fact remains that, before the War, the Indian market was, on the whole, very well catered for and its special requirements were adequately met. Most British makers were represented by leading firms of merchant agents in India, and any blame which attaches for lack of zeal or enterprise should be laid at the door of the agent rather than at that of the shipper. Each cold weather great numbers of travelling representatives visited India on behalf of British exporters, and so maintained very close touch with the changing requirements of the country. The very fact that foreign competition, which had become so keen in other Eastern markets, had made little headway in India, is a fairly conclusive proof that our trade with the great Dependency was resting on sound and permanent foundations and was likely to be maintained.

This was the position of our trade in India when hostilities broke out in August, 1914. During the first year or two of the war, comparatively little disorganisation was experienced, and the volume of our shipments to India was maintained in a most remarkable manner. In 1916, however, the organisation of the industries of this country for the manufacture of munitions afforded a rapidly diminishing surplus for export, and when to this was added the necessity for curtailing the use of tonnage, it became obvious that India could no longer rely on the United Kingdom for a very great range of articles which were necessary for her economic life. In the meantime, the prosperity of India was increasing rapidly after the first shock of war. The monsoon of 1916 was an abundant one, and crops were heavy. A brisk overseas demand at high prices for such staple Indian products as raw cotton, indigo, shellac and saltpetre operated to the benefit of the cultivator and exporter alike. Unlimited quantities of hides were required for the manufacture of boots for the new armies. The insatiable demand for sandbags in Europe brought a period of prosperity to the jute industry without parallel in its history, while the cotton mills in Bombay and elsewhere were fully engaged on highly remunerative work. This great wave of industrial activity brought with it an extraordinary demand for plant, stores and supplies which had to be imported from overseas, and India woke to the fact that she had been entirely dependent on one source of supply for these materials, and that source was cut off owing to the exigencies of war. She turned in the first place to Japan to fill the gap.

The history of Japanese trade with India during the past five years is a remarkable one, alike for the extraordinary progress

made during the years of war, and for the equally striking, but nevertheless inevitable, collapse during the past 18 months. In the last pre-war year, Japan's shipments to India amounted only to £3,000,000, or 2½ per cent. of India's total imports. From the year 1914-15 to 1918-19, they almost doubled in value each year, until they reached the enormous total of £22,000,000 in the last year of war, and Japan found herself occupying the second place in India's overseas trade. This prodigious expansion was followed last year by an equally remarkable decline. Japanese shipments were reduced by almost one-third, and in view of the severe economic crisis through which she is passing, it is only to be expected that a further setback will be experienced this year. Japan has now receded from second to third place in India's foreign trade, and has been overtaken in the race for position by the United States.

Japanese manufacturers have had an opportunity for expansion during the War, which is without parallel in industrial history. Although they enjoyed all the privileges of an Ally, they did not suffer the same handicaps and difficulties which were experienced by the Allies in Europe. On the contrary, owing to the difficulty of securing supplies from the United Kingdom and other European countries, the whole of the markets of the East were open to Japanese products. Competition was largely eliminated, and, so far as India was concerned, Japanese imports of cotton, textiles, metals, machinery and engineering supplies, were encouraged, in order to meet the general shortage. Although Japanese shipments during the War increased in value nearly eight-fold, and although Japanese goods are now to be found in every bazaar in the country, the experience of the past year or so goes to show that Japan has not made the most of an unique opportunity. Japanese shippers were, at first, inexperienced in the needs of the market, and many mistakes and misunderstandings occurred. During the War, owing to the great scarcity of goods, and the consequent high profits made by importers, questions of detail and methods of trading were not so important, and merchants merely grumbled and accepted the goods *faute de mieux*. Now that conditions are gradually approaching the normal, these questions assume more important dimensions, and probably, to some extent, account for the recent decline in Japanese trade. The general opinion has frequently been expressed by prominent importers in India, that now the War is over they are only too glad to revert to their normal channels of supply.

Although Japan is at present experiencing a severe check in the Indian market, and her overseas trade is, at the moment, dislocated owing to the inevitable domestic crisis following the inflation caused by the War, there is little doubt but that she will continue to be an important factor in Indian trade. Japanese goods, consisting in the main of cheap, showy articles for the bazaar trade, have replaced the German and Austrian articles of similar type, and it is likely that they will continue to hold the market, as the cost of production in the Central Countries is bound to increase, and the articles in question are peculiarly suited to Japanese conditions of industry. As regards cotton piece-goods and yarns, Lancashire exporters would be well advised not to lose sight of the possibilities of future competition on account of the present disorganised state of Japan's trade. It is true that there has been a very great falling off in Japanese shipments of cotton textiles during the past eighteen months, and it is probable that Japan will never again reach the position attained in the year 1918-19, when she supplied no less than 35½ per cent. of India's imports of grey goods. But the entry of Japanese bleached dyed, printed and coloured woven goods into the market on a fair scale, is an earnest of the competition which may be felt in later years when the extensions to the machinery and plant in Japan, which are at present either planned or in execution, become operative. The whole question is one of relative costs of production. The comparatively low rates of wages paid in Japan appear, at first sight, to give her manufacturers a considerable advantage, but it should be noted that money wages in Japan have increased enormously during and since the War. Definite evidence is required with regard to the comparative use of *effective* labour in the two countries, *i.e.*, as to the labour cost per pound of yarn or piece of cloth, which alone will determine what advantage, if any, is possessed by Japan in this respect. Industrial conditions, both in this country and in the East, are still too abnormal for any accurate comparison to be made, but the question

deserves the attention of British exporters when the time comes.

More important, perhaps, than the question of the competition of Japanese manufactured goods is that of the competition of Japanese merchants, banks and shipping companies with corresponding British institutions in India. Prominent Japanese export and import houses, such as the Mitsui Bussan Kaisha and others, possessing ample financial resources and good connections throughout the world now have their branches in India, and during the war actually headed the list of piece-goods importers into Calcutta. The Japanese firms are the largest buyers of raw cotton in the country, and, in fact, are dealing in practically every article of export with all parts of the world. They have a very great advantage in the low scale of their working expenses. Assistants and clerks are readily obtained from Japan at much lower salaries than are paid by British firms, inasmuch as their standard of living is lower than in the case of the European. Moreover, these men are great workers, have few interests outside their work, and devote their whole energies to business. They do not object to be stationed in remote districts in the mofussil and to live under conditions which would not be tolerated by the average British assistant, who prefers the social amenities of the ports. They usually acquire a greater proficiency in the vernaculars and appear to understand the subtleties of the Indian mind in a way the average Briton rarely attempts. I doubt whether the British merchants in India realise the formidable nature of the competition which they may have to meet in the future. The Japanese firms are strongly supported by the principal Japanese overseas banks, such as the Yokohama Specie Bank, the Bank of Taiwan and the Sumitomo Bank, all of whom have branches in Calcutta and Bombay.

It is in the sphere of shipping that Japan has probably made the greatest and most permanent advance.

Before the War, Japanese shipping activities were mainly restricted to the carriage of goods between India and Japan, together with such subsidiary services as could conveniently be worked in support of the main traffic. High freights and the shortage of tonnage, particularly during the last two years of War, gave Japanese shipowners a wonderful opportunity, and regular sailings were established from Indian and Ceylon ports to both the Atlantic and Pacific coasts of North and South America, to the Cape, to Java and elsewhere. This competition is particularly serious, inasmuch as Japan was able to preserve her mercantile fleet almost intact throughout the War and extend her shipping services in waters free from submarines at a time when every available British ship was required by the Allies in Europe to maintain their supplies, and when British tonnage suffered such immense losses. The inauguration of these new Japanese shipping lines has also greatly stimulated the trade of Japanese merchants in India.

Briefly, to sum up the situation, it may be said that Japan has enjoyed an unique opportunity of capturing the Indian market in many lines of trade, that during the War period, when competition was not effective, she met with considerable success, but that partly on account of inexperience and faulty methods, and partly on account of the financial crisis in Japan, she is losing a great proportion of the ground gained. On the whole, it would appear that the British shipowner and the British merchant in India have more to fear from the activities of Japanese rivals than has the British manufacturer from the goods made by his competitor in Japan.

The growth of American competition presents a much more serious problem for the British manufacturer. As in the case of Japan, the position gained by the United States in Indian trade is almost entirely due to the disabilities experienced by British producers owing to the War. On the other hand, whereas Japanese trade has fallen away very considerably since it has been possible to secure the goods from this country, that of the United States has made its greatest strides since the Armistice, and now holds the second place. There is no doubt whatever that American competition in India has come to stay. The main factors which are contributing to American success at present are two in number, viz., competitive prices and deliveries and improved service. The ability of American manufacturers to quote lower prices and earlier deliveries in certain important lines of iron and steel, machinery, tools and hardware is largely due to the favourable economic position in which the United States found herself at the close of the War.

American works were able to resume their normal peace-time activities almost immediately after the signing of the Armistice. Moreover, the immediate cancellation of large munitions orders by Washington placed the American steel works and engineering shops in a position where they had either to discharge their men and cancel their activities or else secure overseas business without delay. The immediate result was a series of heavy reductions in the price of steel and machinery at a time when British makers were still handicapped by labour demands and uncertainty as to the policy of Government. British prices, therefore, not only remained firm, but in almost every case have risen steadily. It is true that there have been sharp advances in American prices during the past year, but these have, generally speaking, not been greater than the rise in this country.

The question of delivery has also had an important bearing on American success in India since the Armistice. During the early part of 1919, quotations for very early shipment were made by American makers, and although much longer delivery dates are now required, a very material advantage has been secured and considerable orders have been placed for India. In contrast to this, British makers of steel and steel products have frequently been unable to quote firm prices and give hard-and-fast deliveries owing to the constant rises in price of the materials and also owing to a succession of labour troubles. It is practically impossible at the present time to make any forecast as to whether we shall be in a position to undersell American makers in the near future. Both countries are passing through a transitional period of acute dislocation in industry, and it will be some time before the post-war position of equilibrium is reached.

The provision of an efficient service is all-important in a market like India. Before the War American manufactured goods were hardly known in the country. There were very few American merchant importers of high standing, and the facilities for trade between the United States and India were not particularly good. The War, however, has awakened American manufacturers and exporters to the fact that, owing to the value of their home market, they had neglected the possibilties of foreign trade in the past. Several firms of American merchants are now established in India and are doing a considerable business. Improved shipping facilities between both the Atlantic and Pacific coast and India have materially contributed to the expansion of trade. Greater financial facilities are being given by American banks to the export traffic. American commercial travellers are visiting India in great numbers and every importer is inundated with a flood of catalogues and commercial literature of all kinds. It must be admitted that although, hitherto, American manufacturers and merchants have had little experience of overseas trade, and have had the reputation of being most conservative in their terms and methods, they have recently adapted themselves to the requirements of the Indian market in a most remarkable way. For example, in the motor car trade, the policy of standardisation of cars and spare parts, the personal attention given to importers by representatives and mechanics, and the allowances for advertising and general propaganda work have had a most favourable effect on sales. American makers are often more generous than British houses in the commission and facilities accorded to their agents, and as a result of this, they have built up in India among British merchant importers during the past few years a powerful vested interest in American goods, which our manufacturers are finding to be a powerful factor against them in their efforts to re-enter the market. It must be remembered that the British merchant in India is cosmopolitan in his business, and, while naturally, on the whole, he would, perhaps, prefer to distribute British goods, he would, with very few exceptions, readily turn his attention to foreign articles if they showed a greater margin of profit. During the War, British supplies were cut off, and consequently the merchants in India were forced to turn to America for agencies in order to maintain their business. The War period was one of scarcity prices and very large profits were made on the sales of American goods. As a result, in many cases, the British maker who wishes to appoint good agents finds that some of the most suitable British firms of distributors in India are devoting the whole of their resources and organisation to the sale of American goods.

A further result of American activities in India of late years is the growing feeling among certain sections of the Indian public

that the United States is the only country which can economically produce certain types of plant, machinery and tools. This is not to be wondered at, as British manufacturers in many cases have not been able to ship to India or even take orders for some years, during which time their American rivals have been most active, not only in promoting the sale of their goods, but in carrying out general propaganda. The fact that the British manufacturer has been engaged in supplying the sinews of war for five years and has had to sacrifice his normal business to more fortunate rivals receives little recognition among Indian buyers, and it is only by a campaign of active representation and salesmanship in India that the position can be regained.

I consider that American competition, particularly in iron, steel, machinery, tools, hardware, electrical supplies and motor vehicles, will continue to be severe and may grow in intensity. It will be a fair, straightforward rivalry, and the result will entirely depend upon the ability of our manufacturers and distributors to provide as suitable goods at a lower price. India is an open field, where sentiment plays little or no part, so it would be unwise to count on any preference being shown for our goods, although it is possible that, here and there, Imperial feeling may be met with. Assuming that our industrialists are in a position to quote competitive qualities, prices and deliveries, the only way successfully to meet American competition is to be actively represented by a trained staff in India, whether by the maintenance of the exporters' own branches and distributing organisation, or by the employment of energetic agents aided by salesmen and experts from the home works.

I will now briefly touch upon the most important and far-reaching of all the changes brought about by the War. I refer to the recent industrial renaissance in India. The visitor to India to-day would see a remarkable change in the industrial position of the country, and the outlook of its business men, as compared with 1913. Prior to the War, with the exception of the mining industry, and the jute, cotton and woollen mills, which had gone through a chequered career, very little development had taken place in Indian industries, with the result that when hostilities broke out it was found that not only was the country dependent upon overseas supplies for the bulk of its requirements of manufactured goods, but that the few industries which existed were dependent upon imported machinery, stores, and even materials used in their daily working. During the first two years of war, comparatively little dislocation was caused, but when the need for restricting exports from the United Kingdom became insistent in order to conserve tonnage and also to free the British works for the manufacture of munitions, it was realised by the Government of India that active measures would be necessary in order to stimulate the local production of munitions and supplies for the Indian Army. Accordingly the Indian Munitions Board was formed in 1917, under the able leadership of Sir Thomas Holland, and Government adopted the two cardinal principles which had been laid down by the Indian Industrial Commission as the basis for their constructive proposals, namely :—

(1) That in future, Government must play an active part in the industrial development of the country, with the aim of making India more self-contained in respect of men and material ; and

(2) That it is impossible for Government to undertake that part unless provided with adequate administrative equipment and forearmed with reliable scientific and technical advice.

These two principles coincided with the modern Imperial policy of stimulating the development of all local resources for the benefit of the Empire as a whole. I will not deal here with the excellent work done by the Indian Munitions Board, as its activities are set out at length in its own handbook. I will merely say that the Board exercised a very great influence in stimulating a local desire for industrial development in India. It was not until hostilities ceased, however, that it became possible to translate this desire into solid action. I have already stated, at an earlier stage, that during the last three years of war, India had been extraordinarily prosperous. Large fortunes had accumulated, but so long as war conditions continued there was little outlet for their investment. The Armistice was followed by a period of uncertainty, until, in the spring of 1919, there commenced the greatest industrial boom which India has ever known, and this continued until the end of the year. The wealthiest and most

influential British, Parsi and Indian firms threw themselves wholeheartedly into industrial ventures all over India. Flotations were heavily over-subscribed, and shares went to a substantial premium at once. During the year 1919-1920, 906 companies were floated, with an aggregate capital of £183,000,000. One of the most encouraging features of the boom was the readiness of Indian capital to subscribe to new industrial ventures, provided there was confidence in the names of the promoters or managing agents. As is usual in share booms of this nature, there was a tendency towards over-capitalisation, and many concerns were floated whose prospects were largely based on war conditions. On the whole, however, the general prospects of the companies are good, and although the shares were run up to ridiculous figures, the recent heavy fall in quotations has brought them to a more reasonable level. The new companies cover a wide field of activity, but the greatest development has been in the coal, jute, cotton, engineering and motor industries. Many of the new trading companies are doing quite well, and are paying dividends, but owing to the long deliveries required by makers of machinery and plant, a great number of the industrial concerns will not be in working order for a year or more, and we shall not be able to gauge the full effects of the development for some years.

This remarkable industrial development of India, coinciding as it does with similar movements in other parts of the Empire deserves very careful study by British manufacturers and export merchants, as it affects them in a number of ways

In the first place, it is certain that the imports of many articles which can be manufactured locally, but which were formerly imported from the United Kingdom, will be reduced. This will entail some readjustments of our exports to India, and it is possible that certain firms may be seriously affected by Indian competition for a few years, until they adapt themselves to the changed conditions. On the whole, however, I feel confident that the reduction in our trade in certain articles will be more than offset by the increased demand, spread over a wider and higher range of commodities, which must inevitably result from the increase in the purchasing power of India, due to enhanced prosperity.

The development of many industries, and particularly the iron and steel, engineering, chemical, electro-chemical and electro-metallurgical industries, will provide great scope for British financiers and industrialists to erect works in India, and so take the fullest advantage of India's natural resources for the good of the Empire. India possesses raw materials and unskilled labour, but urgently requires directing force and ability, experience of modern and scientific conditions of industry, and expert foremen and artisans to train the available labour. These can only be provided from overseas, and it would appear that unless British financiers and manufacturers are prepared to seize the opportunities offering, there is a risk that foreign interests may become established in the country. There is one important point which should not be overlooked, and that is the strong current of national feeling in India. The cry of "India for the Indians" is heard, not only in reference to a greater measure of political autonomy, which has already been granted, but also with regard to industrial ventures. It is a natural and perfectly legitimate aspiration, which deserves every consideration. I hold that it is in the highest degree essential that these national sentiments should be studied and borne in mind by British *entrepreneurs*, and that nothing should be done to alienate Indian sympathy and goodwill towards a development, the major benefits of which will redound to the advantage of the country. Subject, therefore, to reasonable control in order to safeguard the interests of the promoters and managers of the enterprise, British manufacturers who contemplate the erection of works in India, would do well to secure Indian capital in their undertakings, and wherever practicable, to allow it to be represented on the Board of Directors, in order to secure that friendly co-operation which is invaluable in dealing with many local problems the most important of which is that of labour. We are hearing a great deal to-day of the movement by a certain section of the Indian community towards what is termed non-co-operation. In the industrial and commercial world in India, we have had too much non-co-operation in the past. The most pressing need of the day is for much closer and more friendly co-operation between European and Indian interests in the industrial development of

the country. This is not a mere question of sentiment, but is one which will profoundly affect the success of individual enterprises, and will bring us nearer the goal which both Briton and Indian have before them—the day when India will take her place as one of the important manufacturing countries in the world, and a source of great industrial, as well as agricultural, strength to the Empire.

Perhaps the most important effect which the growth of Indian national feeling, and the recent industrial developments will have on British trade, is the need for a complete revision of our methods of representation in India in the light of the changes which have been outlined. I have stated that, before the War, the special needs of India were, on the whole, adequately met by our manufacturers and exporters, and that the distributing system which had been built up by generations of merchants was a satisfactory one. This system, however, was designed for a time when our position was unchallenged, and when the market was not so highly developed as it is to-day. The advent of American and Japanese competition, and the feeling of preference which is being shown for Indian-made goods, require that India should be treated with the same attention and painstaking thoroughness as would be the case in any other highly-competitive market in the world. The onus will rest on the British manufacturer to bring down his costs of production to a competitive level, to maintain his unexcelled quality, and, above all, to take a much more active interest in the distribution of his products than he has done hitherto. The old method employed in certain industries of relying on London for orders, without investigating conditions in India, has outlived its day. In the first place, the change now under contemplation by Government, of appointing a Controller-General of Stores in India, with the object of placing Government contracts as far as possible with Indian manufacturers, renders it imperative that our manufacturing engineers and others who have hitherto relied on securing this business, should be represented in India by their own technical men. They would then be in a position to keep in close touch with developments, and would, moreover, be able to render valuable expert assistance to Government engineers and purchasers on the spot.

Prior to the War, the large firms of managing agents in India purchased their requirements of plant and stores through their London offices. This remains the usual method, but it should be noted that enquiries are now frequently sent to New York, and the tendency of purchasing stores from stocks held by merchants in India is a growing one. British makers of industrial stores, therefore, would be well advised to appoint merchant houses in India to carry stocks for them, and to act as their agents. Perhaps the most urgent need is for British manufacturers of machinery and industrial plant to open their own offices in India, staff them with experienced salesmen and engineers and, in the case of heavy plant, with a competent erecting staff. The Indian industrialist to-day is determined to develop on the most modern and scientific lines, and to obtain the most economical and suitable plant which the world produces. His interests are solely those of the industry which he is building up, and he has, therefore, no hesitation in placing his orders with our foreign competitors, if they are able to offer better terms or to give him a better service. He would welcome, however, personal attention by technical representatives of the manufacturer who would aid him with advice as to the lay-out of a plant, who would assist in the supply of complete drawings and alternative schemes, and who would be prepared not only to quote for and accept contracts, but to carry out the erection of the plant, and, subsequently, to keep an eye on its efficient working. Makers who have adopted these methods have met with very great success, but India needs more of them to take the same interest in her requirements. We should not be satisfied until prominent makers of every type of plant in demand in India are represented on the spot by experts. American ideas have been largely introduced during the War, and the fact that the imports of American machinery and millwork last year amounted in value to £3,000,000, or, roughly, 50 per cent. of the value of the British shipments, proves the need for increased British activity and vigilance.

It has been pointed out at an earlier stage, that our trade with India was built up by the powerful merchant houses in Calcutta, Bombay and elsewhere, who were formerly the sole distributors of British

goods in the country. The interests of the greater proportion of these firms are becomng more and more closely identified with the management of local industries, the handling of shipping and insurance agencies, and the export of Indian produce and manufactures. It is true that the distribution of imported textiles being a business on a very large scale, is still in their hands, but, on the whole, there is a strong inclination to confine attention to the most lucrative and least troublesome branches of trade. The result is that the miscellaneous import trade, which, though made up of a variety of articles relatively unimportant, still represents in the aggregate a considerable value, is being conducted in the main by firms of rather less influence and standing. There is need to-day for the younger and more energetic merchants to specialise on the import trade, to obtain a full range of non-competing British agencies in any particular line, and to set up an active selling organisation throughout India. This is being done by a few firms, but there is room for many more. I would particularly commend the suggestion to the attention of those London export merchants who have specialised on India for many years, but who might do well to establish themselves in the country itself. On the other hand the British manufacturer should realise that his agent must be supported in a much more effective way than hitherto, and that it is only fair that the agent should receive more generous treatment in the matter of allowances for travelling, advertising and propaganda work. The most satisfactory method, from the point of view of both parties, is for the manufacturer to send out a trained representative to be attached to the agent's staff in India, who should be employed in giving expert advice to buyers, in travelling widely, and in keeping a vigilant eye on his employer's interests. His services would be of great assistance to the agent firm, and his influence would stimulate them to greater activity.

The remarks made with regard to the absorption of the large merchant houses in local industries, shipping, insurance and exports apply very largely, as is only natural, to the leading Chambers of Commerce in India, whose committees are drawn from the heads of the senior firms, and whose policy is largely controlled by them. It would be of very great advantage to the trade in British goods if those firms who are engaged in it were represented on special sub-committees of the local Chambers of Commerce. The textile trade is strongly represented in practically every Chamber, and special sub-committees exist to deal with its problems, but other important branches, such as iron, steel, machinery, metals, chemicals and the general bazaar trade, have very little voice. I would suggest that sub-committees should be formed in each Chamber to deal with the various divisions of the import business on the lines of those which are being worked so successfully in the British Chambers of Commerce in China and other foreign countries. It is a remarkable fact that the Chambers of Commerce in India are not rallying points for British trade in the same sense that the British Chambers in China and elsewhere are. The Chambers in India are prone to take on Imperial economic questions a rather local and detached view, which is not calculated to further our Imperial interests in the way they deserve to be furthered.

I would now like as briefly as possible to deal with the present condition of the Indian market, which is giving rise to some anxiety in business circles. The latest advices from India show that the country is passing through a period of great stringency. Shipment of country produce is being held up owing to the stagnation in the consuming markets of Europe and America. This, in turn, has reacted on the import trade, and clearances in India of imported goods during the past few months have been practically negligible. In the meantime shipments have been regularly arriving from abroad, with the result that there is in the ports an almost unprecedented congestion of goods, and stocks are very high despite the fact that supplies in the country districts are on a moderate scale. The fall in exchange during the past few months has very greatly hindered the clearance of goods. Dealers who had made their purchases at a time when exchange stood at 2s. 3d. and upwards now find themselves faced with a smart loss if they sell their goods, and consequently they decline to meet their obligations and take up their drafts, preferring to hold the goods on the chance of a recovery in the rate. The slump in the values of practically all classes of shares, which was the inevitable conclusion of the reckless inflation during

last year's industrial boom, is another factor which has largely contributed to the present stagnation.

Throughout the whole of the East, from Bombay to Yokohama, there is at the present time a very serious state of congestion in trade, with severe financial stringency. In my opinion, the depression in India should be merely a temporary one. India, considered statistically, is in a much stronger position than other Eastern markets, and it is hoped that if only confidence is restored and stocks begin to move into consumption the outlook will be much clearer towards the end of the year. It is possible that the sharp fall in exchange during the last week may bring the Indian dealers to their senses and induce them to take up their drafts. Certainly the reports from India during the past few days have been slightly more encouraging and the recent purchases for India on the Manchester market, although they are as yet not on a large scale, show some confidence in the future. In the meantime, the greatest care should be taken by exporting houses in this country not to add to the present difficulties by shipping goods which they may have reason to fear will not be taken up. The Eastern Banks are carrying a very great financial burden in all countries of the East at the present time, and it is incumbent on the exporter in this country to realise this fact and to modify his commitments, as far as possible, until the position improves.

Despite the present difficult situation in India, which I feel convinced is a temporary one, being due partly to the fluctuations of exchange, partly to reaction after a great industrial boom, and mainly to depressed and uncertain world conditions, I still believe that the general state of the country is good and that there is cause for sane optimism in viewing the future. The present monsoon, although it cannot be termed an excellent one, is quite a fair average. The country is still short of a great variety of goods, notwithstanding the present stocks in the ports, but purchases have been withheld owing to the high rupee prices at current rates of exchange. When the present abnormal situation is cleared, as I hope and believe it will be in a few months, I look forward to India continuing along the path of material progress in which she has made such enormous strides during the past few years, and I have little doubt that British trade will be able to maintain and extend its position and will materially contribute to the prosperity of a new and transformed India.

DISCUSSION.

THE CHAIRMAN (Sir Charles C. McLeod), in opening the discussion, said that he hoped manufacturers, many of whom were present at the meeting, would take to heart what the author had said about other countries and the special care they took in educating consumers. There was no more important part of the paper than that in which the author said: "The foundations of our pre-war predominance in trade with India were solid and well laid, and represented the outcome of years of enterprise, sound trading and integrity on the part of manufacturers, exporters and distributors, both in this country and in India." This was an assurance to British manufacturers, that if they maintained their past reputation, they would find that the place they had at present more or less lost, not through any fault of their own, would soon be regained. He was glad the author had given the Eastern banks credit for helping to finance the burden which had fallen upon British exporters Mr. Ainscough had pointed out that, while at present domestic troubles in Japan had rather cooled off its trade with India, they must be prepared to see renewed activity when the Japanese had settled their own local affairs. News from the other side indicated that there was already, not only in the export trade from Japan to India but in the export trade of India, a condition of things that would need to be very carefully watched. What was even more important, from the point of view of the British manufacturer, was the entrance of America into the Indian trade. America obtained a footing as Japan did, during the war, and soon became aware that India was an unequalled field for her goods. She had taken full advantage of her opportunity. Those who had been in India lately must have noticed that the American exporter was careful to send out to India men who knew their business. For instance, motor cars had now become a very great trade in America. The Americans sent out sample cars and distributed them so that prospective buyers could see for themselves what they were going to get. He was recently taken to task in the Indian newspapers for saying at a meeting that the increase in India's imports of motor cars would be very large in the next five or ten years. At present from 30,000 to 50,000 cars were imported into India. He stated on the occasion alluded to that within five or ten years the number would go up to something like 200,000, and that the largest proportion would come from America. Some of his critics thought that that estimate was rather sanguine, but the total number of cars entered during

last year was over 9,000, and of these no less than 8,353, valued at 230 lakhs, out of a total value of 262 lakhs, came from the United States; in other words America supplied seven-eighths of the cars that went to India. The later figures were still more significant. In July last 5,292 cars were landed in India, 4,015 of which were American. The Americans had awakened to the fact that standardisation of their goods would help them to produce those goods at a much lower cost, and that appealed to a great many Indian users. The author had mentioned the very substantial advance recently made in Indian industries. During a visit to India in the last cold weather, after an absence of six years, he was positively astounded at the difference. Calcutta and Bombay were now huge cities; all the old buildings had been razed to the ground and large modern structures erected. Even then he was informed there was nothing like proper accommodation for business purposes. The author was of opinion that although some of the many Indian companies recently floated might not succeed, the great majority would. He agreed with that statement, because of the knowledge obtained in this country during the last ten or fifteen years by Indian merchants. They had also learned from British merchants in Calcutta and Bombay how to build mills and carry them on. That British engineers and other manufacturers seemed to be averse from taking Indian students into their works and factories was, in his opinion, a very short-sighted policy. Neither Japan nor America refused those facilities; in fact, they were only too glad to accord them. The consequence was that, when the students went back to India they ordered goods either from Japan or from America. He hoped that Sir William Meyer, when purchasing stores for India through his Department, would make it a *sine qua non* that those people from whom he bought stores should receive into their works a certain number of Indian students so that they might gain experience. The author had carefully avoided, except for one small reference, the subject of exchange. It was, however, the most important factor at the present moment. It was announced in that morning's issue of the *Times* that the Chambers of Commerce and all the Bombay merchants and brokers, were petitioning the Government of India to restore reverse councils. This, if it were not so serious would be amusing, as the same people denounced reverse councils when the Currency Committee's report was published. Reverse Councils had cost the Government £55,000,000, and it appeared to many business men that it would not have been against the Currency Committee's recommendations had the issue of reverse councils been limited to a period when exchange was in danger of falling under 2s., rather than that it should have been started when exchange was at 2s. 11d. In spite of all those difficulties and there not being a very good monsoon, he confidently expected that India would soon find a way of recovering. He was not, however, so sanguine as the author, who thought that that would happen in a few months. If it happened in eighteen months most people would be quite content.

Sir Charles H. Armstrong (Chairman of the Great Indian Peninsula Railway Company), after stating that in general he was in complete agreement with the paper, said he thought the author had been a little severe on British Chambers of Commerce in India. Apparently Mr. Ainscough's idea was that the function of a British Chamber of Commerce in India should be to push trade in various directions, as was being done by British Chambers in China and other parts of the world. Personally he was not quite sure that that was the function of British Chambers of Commerce in India. They were there to guide and to encourage trade and to protect the interests of their members, a work they did extraordinarily well. They had possessed for many years the full confidence of the Indian trading community, which showed that they were doing their work with tact. Japanese competition during the war was very serious, and at one time it looked very much as if British trade would suffer materially, but there was a heavy slump in Japan at the present time, which would take many months for her to get over. India also saw her own opportunity during the War, but he was not certain that she took advantage of it to anything like the extent she might have done. As the author stated, during the year 1919-1920 906 companies were floated in India, with an aggregate capital of £183,000,000, while in the first nine months of the previous year 158 companies were floated with a capital of about £5,000,000, which was very much in excess of the pre-war average. Last January, when he was in Bombay, companies were being floated at the rate of two or three a day, and if the directors had the confidence of the public the money was at once subscribed. That seemed to him to be one of the weak points of the situation, because, although the directors might be men of ability, they could not possibly give more than a fraction of their time to the development of the concerns with which they were connected. It was essential at the present time that Indians should get down to steady work, and unless they did so many of the industries that had been started could not possibly be successful. He was very glad indeed that the author had touched on the important question of co-operation. If only a very small portion of the energy which was put into Indian politics could be diverted to the encouragement and expansion of Indian Industries, it would be a good thing for all concerned. Political differences, which were

very often of a racial nature and brought about by misunderstandings, were the greatest hindrance to trade development on sound lines. He was quite sure, however, that there would always be a large number of the Indian trading community who would realise the benefit of working in conjunction with British firms in India, and on the other hand he was quite certain there would always be many British firms in India who would realise that a large number of the Indian industrial works could not be successful unless they worked in harmony and in conjunction with their Indian clients. He was not quite sure that he feared American competition to quite the same extent that the author did. It was an undoubted fact that American competition in many articles would be very keen, and in some respects British manufacturers would suffer; but he was inclined to think that when this country got back to ordinary conditions its Indian clients would place their orders with us. Our firms had a very great reputation for first class articles, a reputation which had been built up over many years, and Indians knew we carried out our contracts with precision. This was a very valuable asset. The great need in this country at the present time was industrial peace, because it was impossible to carry on foreign trade satisfactorily when our manufacturers could not quote firm prices and state the month in which they would be able to give delivery. The author had stated that the railways in India had been built and equipped to British standards and according to British practice, and that they were managed by experts sent out from this country. Those railways were working in a very high state of efficiency, which must be maintained. A Commission appointed by the Secretary of State would visit India during the cold weather for the purpose of enquiring into the future of Indian railways and making recommendations. He sincerely hoped that no recommendation would be made which would tend to lower the present efficiency of the Indian railways, or which might tend to divert orders from British manufacturers to the manufacturers of other countries. That was a very important point which he thought ought to be kept carefully in mind.

Sir William H. Clark, K.C.S.I., C.M.G. (Comptroller-General, Department of Overseas Trade), said he was very glad to be able to pay a tribute to the author's clear and precise picture of the present-day conditions of British trade with India. Perhaps the most frequent complaint heard at the Department of Overseas Trade was that the British business man hardly knew, under present circumstances, where he was, this being due entirely to the war, which had changed the channels of distribution, turned a great producing country into a vast works for the manufacture of munitions, and compelled a great marketing country like India to look elsewhere for its supplies. The competition of Japan and the United States had created a new situation in India, which would have to be dealt with in the future. Reference had been made to the injury which was being done to British trade by the difficulty manufacturers found in quoting firm terms and dates of delivery. The Department of Overseas Trade received complaints in that direction from British merchants and foreign buyers not only in India but throughout the Far East, and it was having a very great effect in preventing the spread of British trade. Now that orders were falling off it might be worth while for manufacturers to take risks, because the prices of materials were more steady than they had been and were even beginning to diminish. Another point which had to be borne in mind was the great change which had arisen from the spread of industrialism in India itself. When he left India that was little more than an ardent aspiration. He wished the author had had more time to give details of the class of works that had been established and of how the parodoxical difficulty of the perpetual shortage of industrial labour had been overcome in India with its 300,000,000 inhabitants. The starting of industries in India would prove to be the great solution of some of our trade difficulties. There were two ways of doing trade; firstly, sending goods to a country, and secondly sending capital there with which to start industries and producing goods on the spot. Both those methods had been adopted in the present case, but there was scope for their further development, and he was sure that co-operation with the Indian in such work was going to be a matter of vital importance. He had always thought that the fact that there had not been sufficient co-operation in the past was one of the few mistakes that had been made in India, because it gave colour to the perpetual charges that were heard of exploitation of India for the benefit of the United Kingdom. While he would not risk recommending anything so subversive as transferring the Boards of the Indian railways to India, one frequently heard the complaint that India did not have a sufficient voice in the working of its own railways. It was not necessary to lay stress on the vital importance of the Government and the mercantile community combining to maintain our great supremacy in the Indian trade. The British Government had done their bit to help in the last two or three years, but the scope of Government assistance must be limited. It ought to avoid interference, but it could do something by the supply of intelligence and generally in smoothing away difficulties, and it was with that object that two years ago it appointed Trade Commissioners in India.

He thought the Department might take some credit for that, because it was suggested at the time that the step was unnecessary in a country like India, where we already held such a great preponderance of trade and possessed such an efficient organisation. It seemed to the Department, however, in view of the changes that were taking place, that it was desirable to have their own men on the spot, who could study the movements of trade in a way which it was difficult for those actively engaged in some part of it to do, and he was glad to think that in the present instance the Government had not, as sometimes happened, done the right thing at the wrong time. It had appointed officers to give advice and information during the period of transition, and he hoped that in the future the trade of India with this country would be as strong, flourishing and fruitful as ever it was in the golden days of the past.

MR. THOMAS MCMORRAN said he desired as a member of the commercial community to express his appreciation of the interesting historical survey the author had given and of the practical nature of the paper. It was, however, rather a surprise to those intimately concerned with the trade of India to find that their blind belief that Germany was, before the war, steadily pressing on to subvert British trading activities in India was based on a misconception, and he was not sure that the author's statement that in many cases the Germans relied upon the profits they made in their monopolies of the hides and dye stuffs trade to obtain a footing in the miscellaneous import business quite coincided with the actual facts. Much of the German progress was, he believed, due to hard work. He strongly commended to those young men who went out from this country the necessity of considering business as their first interest and pleasure as a somewhat secondary one. Most people desired a good time during life, but the Empire had come through a period of war and it was now essential that everybody should work hard, and he would like to feel that British representatives in India were going to keep up the old standard and show those personal qualities which were the best thing for impressing on the Indian mind the desirability of intercourse with good old England. New competitors had entered into the bazaar trade. If the Germans had gone out, the Japanese had come in, and behind all that there was still the potential competition of Indians themselves. He should be very glad if both the Germans and the Japanese could be displaced in connection with a large proportion of the many articles required for the people of India. It only needed a little imagination to realise the immense possibilities that existed for trade with a population of 300,000,000. He desired to support what Sir Charles Armstrong had said with reference to British Chambers of Commerce in India. He thought the reason why British Chambers of Commerce in India differed somewhat from those in the Far East was the fact that they had always identified themselves with the interests of India and not necessarily to the same extent with the commercial interests of Great Britain. He was glad they had done so, and he hoped the fact would be appreciated by Indians, as he believed it was. The efforts made by Chambers of Commerce to further the development of industries in India were not necessarily inimical to the interests of exporters on this side. It was necessary that those who had had some experience of industrial development should endeavour to promote such work in India and to the best of their ability incorporate Indian effort. He had been much interested in the great industrial development in India and the boom which had recently occurred in the flotation of companies. In the old days of the gold boom there were hardly any prospectuses, but nowadays a prospectus was issued, a conspicuous feature of which in many cases was the absence of any intimation about the company except the general statement that great profits would be made. He could quite easily imagine that some of the sharp people in London who prepared prospectuses in this country had gone to India and floated companies, amassing much wealth. He did not think, however, that anything could be more harmful to British interests in India than that financial adventurers, who in many cases were the scum of London, should go to India and exploit it for their own advantage, and he hoped the Indian community would be warned of such efforts. Those who were desirous that the British name in India should not be soiled should see to it that adventurers of that kind were kept out of India. With regard to the very important question of exchange, he thought everybody would have great sympathy with what the Chairman had said about reverse councils, but in view of the lateness of the hour he thought it would be unwise to attempt to enter upon a discussion of the subject.

SIR CHARLES H. BEDFORD, LL.D., D.Sc., said the extent to which transport conditions entered into the commercial and industrial life of a country required no emphasis, and side by side with that was the question of the driving power for transport. The question of fuel supplies in India was always one of great difficulty. Most of those present had some experience of how the production of coal had progressed, and they knew to what a small extent relatively the oil resources of India had been developed. Only $1\frac{1}{4}$ per cent of the oil supplies of the world came from India. We were now living at the start of what might be termed the Cellulose Age, and there was an immense field for the development of cellu-

lose fuels. A great deal of research work was at present in hand with regard to the gasification of cellulose substances, and a good deal of attention was being devoted to the question of alcohol as fuel. The potentialities of India in the last category were simply unrivalled, because there was no country—not even China perhaps—which could compete with it. Large tracts of land near waterways were under waste vegetation in India; they were in ready touch with centres at which distilleries or other factories could be erected, and the deltaic areas of Lower Burma and the Ganges afforded unique areas for the development of those fuels. The whole world was at the present moment crying out for motor fuel. It was painfully aware of the soaring prices of petrol and benzol, and the fact must be faced that the oil interests were masters of the situation at the present moment. There was an ignorant cry in the papers in regard to the control of mineral fuel resources, but the fact was forgotten that those resources lay without the confines of the British Empire. He was at the present moment in charge of a large experimental concern in India for producing alcohol for power and industrial purposes from waste vegetable materials, and the potentialities were very great indeed. If it was borne in mind that, next to water, alcohol was the greatest solvent, it would be possible to understand what the potentialities were. The Government of India had, so far, shown the most generous and liberal spirit in dealing with the subject, and had at his request set up an expert Committee to study the bulk storage and transport conditions of alcohol, so that when the time came for large quantities of it to be produced and marketed it would not be necessary to wait for any drastic modification of governmental regulations. He hoped the very important factor of a cheap and ample supply of indigenous liquid fuel such as alcohol, to which he had called attention, would not be lost sight of in any consideration, however wide, of British trade with India.

Mr. D. T. Chadwick (Indian Trade Commissioner) said the author had mentioned three subjects which would have an influence on British trade with India, namely, Japanese, American and Indian development. The first two he looked upon as somewhat to be feared, but it was a great pleasure to everybody that he had welcomed the last. In that connection he had laid stress on a material point, namely, that the development of industries in India and the consequent rise in the economic standard of life of the country would mean an increased demand for foreign goods of a higher grade, whereby the manufacturers of other countries would benefit, a fact which was frequently forgotten by manufacturers in England. He had looked through the figures of the imports of piece-goods into India and found that, in spite of the big development of the Indian mills in the last 25 years, just prior to the war India was importing more British piece-goods than at any time within that period. He supported the author's plea for co-operation in the attempts which were being made to establish industries in India. India needed the technical skill, advice and co-operation of the best manufacturers of this country. He urged them not to look so much to establishing branches of their own businesses in India, but to form Indian companies and thus become more intimately associated with the people of the country. If that were done it would be possible to bind the commercial and material interests of India more closely with those of this country as years went on.

On the motion of Sir John O. Miller, K.C.S.I., seconded by Sir Charles S. Bayley, G.C.I.E., K.C.S.I., a vote of thanks to Mr. Ainscough was carried unanimously.

Mr. Ainscough expressed his appreciation of the interest which had been taken in the paper and of the reception given to him. In view of the lateness of the hour he stated that he would prefer to reply in writing to the points which had been raised.

Mr. Ainscough writes:—

I regret that Sir Charles Armstrong and Mr. McMorran consider that I have been rather severe in my references to the attitude of the European Chambers of Commerce in India. I quite agree that their main function is to guide and encourage trade and to protect the interests of their members, and, on the whole, I think they perform this function remarkably well. What I wished to emphasise was the need for sub-committees in each Chamber to deal with the various divisions of the import trade in the same efficient manner in which the piece-goods sub-committees serve their members. A special sub-committee of the Bengal Chamber which was recently appointed to consider this question, admitted that more might be done in this direction, and I would like to commend the suggestion to the attention of the other Chambers in India.

I am glad that Sir Charles McLeod referred to the desirability of attracting Indian students of the right type to our engineering works and factories so that they might acquire British methods and practice. There are grave difficulties at the present time owing to the large numbers of ex-service men, for whom places must be found and who have a prior claim. It is, nevertheless a subject which merits very careful attention. The nucleus of an organisation exists in the shape of a special department of the India Office to deal with Indian students in this country. Some progress might be made if to this department were attached an advisory

committee of leading British manufacturers who would facilitate the placing of students in selected works.

Mr. ALFRED DICKINSON, M.Inst.C.E., M.I.Mech.E., writes:—

Mr. Ainscough has done good service in drawing attention to the desirability of a closer alliance between British and Indian manufacturers and merchants.

His statements as to Indian industrial development demonstrate that India has awakened and means to take her full share in that development. My view is that the Indian manufacturer and merchant would welcome partnership with the Briton in industrial development.

The Indian understands the markets, the labour, and the needs of the people. The Briton understands methods of production and organization. Given sympathy and trust between the two, the possibilities for industrial development are vast.

It has always been an enigma to me why British manufacturers care so little and know so little of the possibilities of industrial development in India.

Take, by way of example, the textile industry I have spoken to several Lancashire manufacturers about Indian development in their own industry, and invariably I get the reply. "Oh! They can only spin the coarse counts." The Indian at present spins to suit his market: he can and will spin the fine counts when the demand arises, and then, unless the Briton is with the Indian, he will be once more cursing the fates which have been so unkind to him.

POTTERY INDUSTRY OF SWATOW.

Chinaware, both coarse and fine, and pottery and earthenware, are made in the Swatow district to meet the demands of the export trade, as well as to supply a large portion of the local requirements. The bulk of the exports is sent to the South Seas, the Straits Settlements, and Siam, chiefly for the use of the large Chinese communities there, the earthenware usually being exported in the form of containers for food and other products.

The chinaware manufactured in this region, writes the U.S. Consul at Swatow, is generally of an inferior quality, and is made into articles of everyday use. The making of earthenware is of ancient origin, while the chinaware industry was started only some 30 years ago.

In the village of Fengchi, about three miles south of Chaochowfu, the sole industry is the making of earthen and chinaware, in which over 2,000 workers are employed. The clay for the earthenware, which is dark brown in colour, is secured near the village. At some places the top soil of arable fields is removed temporarily and the clay beneath obtained. The potter's wheel, operated by the hand or foot of the potter, or by a boy helper, is used for forming the pieces, large and small, but in the case of large pieces sections are made first on the wheel and the finished article produced by pounding or hammering the sections together. All kinds of household receptacles are made. The annual production at this village is estimated at £40,000.

The clays used in making chinaware are obtained in the hills near Chaochowfu and are carried by boat to Fengchi at a small cost. It is understood that a much better clay is found in the Hakka region. The manufacture is carried on by native methods. The white hard-lump clay is pounded by man power, usually in a rice-polishing mortar, for 48 hours, after which it is soaked in water, strained and sun-dried. The other variety of clay dissolves in water without pounding. Both require kneading before being moulded, and shaped on the potter's wheel. A first-class labourer working 12 hours a day can turn out 200 bowls or saucers, and an ordinary workman can turn out about 100 pieces. If machinery were introduced the output could be increased two or three fold. The articles made are principally cuspidors, teapots, wine pots, joss vessels, flower vases, and water jugs. The colouring matter, chiefly blue, is imported. The annual production of chinaware in this village is estimated at £60,000.

There are about 20 kilns at Fengchi, all of the cylindrical staircase type. They are fired with pine branches brought from the Hakka country, the firing lasting 24 hours for chinaware and 36 hours for earthenware. During the first half of the time the kiln is fired at its base, at each of the holes on the sides of the roof of the kiln. When burning chinaware, each piece is placed in a perforated earthenware case for protection against the firing. After the firing, the kiln must be allowed to cool before the contents can be removed and other material put in. The cost of building such a kiln is said to be about £400.

The decoration of chinaware is done both before and after firing, and sometimes there is a second firing after the colouring process, but this is not common. Foreign colours are used, although some native makeshifts have been employed, owing to the scarcity and high cost of the foreign colours. Blue is the principal colour, but red, white, green and black are also used. The glaze is said to be produced by treating the article with a solution made of mussel shell lime, which has been burned with rice husks. The value of the annual demand for colours is estimated at between £4,000 and £6,000.

The factories about Kaopi are situated from 9 to 27 miles outside the city. There are about 2,000, varying in size. Together these

give employment to over 7,000 men, in addition to the women and children employed in carrying. The raw material is obtained from nearby places, that produced at P'ing Yuan and Sha P'ing is said to be the best. The Sha P'ing is whiter and tougher. Fuel is also produced locally and costs only 1s. for 133⅓ pounds, making the cost of a complete firing of a kiln about £3 14s. Pounding is done by water power and takes 48 hours. The process is similar to that of Fengchi, except that vats instead of cisterns are used. The products are chiefly bowls, saucers, and cups. The kilns are also cylindrical, but comparatively small, and on account of the topography of the country do not cost more than £60 each to construct. The crockery handled by Kaopi exporters amounts to about £120,000 annually.

MAPLE PRODUCTS INDUSTRY OF QUEBEC.

Official reports show that the maple-products industry in the Province of Quebec has grown markedly during recent years, its development being mainly attributed to the scarcity and increased price of beet and cane sugar. While sugar maples are found chiefly in the central and western sections of the Province, the industry has, to some extent, developed also in the Gaspe Peninsula, the counties of Bonaventure and Gaspe showing in 1919 an output of 59,135 pounds of sugar and 3,101 gallons of syrup, as compared with an output in 1911 of 11,870 pounds of sugar and 512 gallons of syrup. No figures as to quantities are available for the county of Matane, but the value of the products of this industry in the three counties in 1919 amounted to $20,665.

The output in the Province as a whole in 1919 amounted to 12,353,667 pounds of sugar and 1,470,275 gallons of syrup, of an estimated value of $6,396,535, as compared with the 1911 output of 9,989,443 pounds of sugar and 1,005,330 gallons of syrup, of an estimated value of $1,680,393. The United States affords the best market for the product.

According to a report by the U.S. Consul at Campbellton (New Brunswick), an Association known as the Co-operative Society of Pure Maple Sugar and Syrup Makers, organized some years ago, has secured as members thousands of farmers interested in this industry. Its objects are to distribute information among its members as to the best methods for obtaining the highest quality of products and to prevent their adulteration. Through the efforts of this Association, a Federal Act was passed, prohibiting adulteration of maple sugar and syrup, and it was also responsible for the establishment of sugar-making schools, and for exhibitions and competitions in Canadian maple products.

The development of the industry has been further stimulated by the provincial Department of Agriculture, through demonstrations in sugar making in various parts of the Province given by skilled instructors. Five instructors gave a total of 94 demonstrations in 18 counties during 1919.

The Province has three sugar-making schools, which are situated at La Minerve, Beauceville, and Ste. Louise. These schools provide a 15 days' course, the Department of Agriculture paying the board of the students. Last season at these three schools, 12,000 maple trees were tapped, and 808 gallons of syrup, 3,775 pounds of sugar, and 100 pounds of taffy were manufactured. Thirty-three pupils followed the course, and there was an attendance of 786 visitors. The approximate period of the course, depending upon the season and location of the school, is from the 20th of March to the latter part of April.

The 1919-20 allotment to Quebec Province from the Dominion Government, under the Agricultural Instruction Act of Canada, for educational purposes in connection with the maple industry was $4,000.

As the farmers depend to a considerable extent upon the lumbering industry for employment in the winter, which employment terminates about the end of March, and as farm work usually does not commence until the middle of May, the maple-products industry fits in nicely with their other work.

POTASH MINING IN GERMANY.

Potash in Germany occurs in the form of a rock salt and runs in seams of 30 feet or more in thickness. As mined, it has about the same consistency as the common rock salt of commerce, and its grinding is easy. It is ground to about the fineness of a coarse sand; in this form it is used for domestic agriculture, and at the present time it is also mostly exported in this form.

According to a report furnished by an American Consul on duty with the U.S. Mission in Berlin, the depths at which the true potash deposits are situated render it necessary to sink shafts leading to levels of as much as 5,000 feet below the surface. Horizontal cuttings extend up to two miles in length. Owing to the very soluble nature of these salts, and to insure that the impervious covering remains intact, it is necessary so to construct the shafts as to prevent the inflow of water. This is done by means of brick-work lining, or where quicksands are present by a special system involving preliminary freezing.

The miners themselves are, unlike coal miners, entirely free from the danger of fire damp. Occasionally dangers arise from hydrogen, the blue flames of which may sometimes be seen flickering on the walls after a blasting operation in a newly opened mine. Sulphuretted hydrogen has caused the death of a few miners, and carbonic-acid gas renders suffocation

possible. Every mine now is provided with a reserve ventilation shaft. A much more real danger is a sudden inflow of water, and one too, which cannot be neglected. As a matter of fact, several of the more valuable mines have been wholly destroyed through such irruptions. As it was impossible to pump out the water owing to the soluble nature of the salts, these flooded mines had to be entirely abandoned with the consequent loss of all invested capital. A new shaft has to be sunk in such cases sufficiently distant from the old one to eliminate danger from the same source.

Another danger lies in the pressure of the upper strata. The roof has consequently to be substantially supported. The former practice was to support the roofs by pillars of the salts left standing at regular distances, but these were found to crumble away too quickly. The system now adopted is to fill the cavities completely by stowing away waste materials and rock salt from the anhydrite region. Rock salt can be taken from the older deposits, and this salt being less easily corroded than the potash salt, columns of rock salt suffice to support the roof of the formations. This method of refilling the excavated areas entails considerably more expense, but has the advantage of giving perfect security and enabling all the potash to be extracted.

In the actual operations of mining and drilling, blasting is resorted to in order to detach the crude salts fron the parent rock. Both hand and electrically-driven boring drills are used, and electric haulage is employed.

The last normal mining year in Germany was 1913; in that year 5,187,300 tons of potash salts of all kinds were produced. In normal times about 40,000 to 45,000 miners were employed, and in the busy seasons of spring and autumn as many as 5,000 truck loads (of 10 tons each) of salt rock were moved out each day.

GENERAL NOTES.

Purple Dye from Shellfish.—On the Pacific coast of Costa Rica, especially in the region about Cocos Bay, there abounds a kind of shellfish called the "nacascol," from which a fine purple colour is obtained So far, according to a report by the U.S. Consular Agent at Puntarenas (Costa Rica), no way has been found for preserving this dye, and the industry has remained in the hands of the few old people who take the trouble to dye a few ounces of thread every summer. The process is very simple. On picking up the shell from the beach or detaching it from a boulder, the gatherer blows into it, whereupon a few drops of a greenish liquor ooze out. This liquor is collected in a clamshell, and after a sufficient quantity has been collected the thread is passed through it, soon after assuming, on exposure to the sunlight, a beautiful purple colour, which is absolutely fast after it has turned purple. It is thought possible that the dye turns fast only on exposure to the air and that the liquor could be preserved by keeping the air away from it. There is little doubt, in the Consular Agent's opinion, that this industry of dyeing thread could be extended to greater proportions if an extensive demand at good prices could be found for the dyestuff.

Industrial Experimental Laboratory in Mexico.—The Mexican Ministry of Industry, Commerce and Labour have formally inaugurated an industrial experimental laboratory in connection with the commercial museum. The new laboratory is complete in every detail and is intended to offer opportunity for instruction in modern processes of manufacture to persons with small capital who are desirous of turning Mexican raw materials into manufactured products. There are in connection with the laboratory fully equipped machine shops, carpenter shops, and tin shops, with a corps of instructors for each different department, and regular courses in the various industries likely to be profitable in Mexico are to be offered to students and other interested persons.

The Dependencies of the Falkland Isles.—The report of the Interdepartmental Committee on Research and Development in the Dependencies of the Falkland Isles [Cmd. 657] contains a great deal of important information relating to South Georgia, the South Orkneys and South Shetlands and adjoining seas. It includes some of Dr. W. S. Bruce's hitherto unpublished researches on the early history of the sealing industry in the South Shetlands, and, among other reports, the Commercial Uses of the Products of the Whaling Industry; the Present Position of the Southern Whaling Industry, by Sir Sidney Harmer; and Memoranda on the Methods of the Industry, by Mr. T. E. Salvesen and Captain C. A. Larsen. The Committee recommend that two vessels, provided with competent scientific staff and full equipment, should be employed to carry out research in the habits, distribution and migration of whales and seals; in hydrography, meteorology, geology and zoology, with a view to the development of whaling and sealing, and the possibility of mining, commercial fisheries, reindeer breeding, etc.

The West Indian Tropical Agricultural College.—The projected West Indian Tropical Agricultural College is to be placed in Trinidad. The site chosen is on Government land at St. Augustine, about six miles out of Port of Spain, according to the *West India Committee Circular*; it will stand on a spacious pasture of about 60 acres in extent. Within one-third of a mile of the College site are one of the Experimental

Stations and the Government Farms of the Trinidad Department of Agriculture. At the former about 150 acres are reserved for experimental work, some 61 acres being already for large scale plots of sugar cane and other plants. The College will thus be in a position, when erected, to start immediately, under very favourable conditions, practical work and research in connexion with the principal West Indian crops. The College Committee has decided that the promises and prospects of support by the Legislatures of the various West Indian Colonies are sufficient to justify them in proceeding with the necessary steps towards the establishment of the College. Those Colonies which have so far promised aid are Barbados, Trinidad and Tobago, Grenada, St. Vincent, St. Lucia and the Leeward Islands. It is hoped also that British Guiana, Jamaica, and British Honduras will when the matter is brought before them officially approach it in a broad-minded way and give assistance to the scheme. As the *Circular* remarks, the next step will presumably be to nominate a provisional governing body and to incorporate the College and, provided that no time is lost, it would now appear to be reasonably certain that the British West Indies will be ahead of Ceylon and other eastern British Colonies in establishing a much-needed Tropical Agricultural College.

Coal Mines in Northern France.—The clearing of the pits at the Dourges mines of Northern France is being effected without difficulty. According to *The Engineer*, 225 tons are now being extracted daily at the Haly d'Assil pit, and the cleaning up, down to the 295 level, will be finished within a few days. The Sainte Henriette and Darcy pits are not yet yielding more than 30 to 50 tons daily. The total production of the 2,700 miners engaged amounts to 70,000 tons monthly, or about one-tenth of the pre-war output.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock (unless otherwise announced):—

December 1.—Miss Louisa F. Pesel, President of the Guild of Embroideresses, "Embroidery: National Taste in relation to Trade." Sir Cecil Harcourt Smith, C.V.O., LL.D., Director and Secretary, Victoria and Albert Museum, in the Chair.

December 8 (at 4.30 p.m.).—E. A. Brayley Hodgetts, Chairman, Russian Section, London Chamber of Commerce, "A Retrospect of the Personal Influence of Britons in Russia." The Right Hon. Lord Carnock, G.C.B., G.C.M.G., G.C.V.O., K.C.I.E., Ambassador to Russia 1906-1910, in the Chair.

December 15.—Major-General The Right Hon. Lord Lovat, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., "Forestry." The Right Hon. The Earl of Selborne, K.G., G.C.M.G., President of the Board of Agriculture 1915-1916, in the Chair.

Colonial Section.

Tuesday afternoon, at 4.30 o'clock:—

December 7.—A. H. Ashbolt, Agent-General for Tasmania, "The Trade of Australia during and after the War."

Papers to be read after Christmas:—

Sir Marcus Samuel, Bt., "The General Position of the Oil Question."

Lawson, F. M., Assoc.M.Inst.C.E., "The Future of Works Management." Sir Robert A. Hadfield, Bt., D.Sc., D.Met., F.R.S., in the Chair.

A. F. Bailie, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World." Professor Sir John Cadman, K.C.M.G., D.Sc., in the Chair.

A. Abbott (Department of Scientific and Industrial Research), "The Origin and Development of the Research Associations Established by the Department."

Sir James P. Hinchliffe, "Research in the Wool Industry."

Sir Herbert Jackson, K.B.E., F.R.S., "Research in Scientific Instrument Making."

William Cramp, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice."

Charles S. Myers, M.D., Sc.D., F.R.S., Director of the Psychological Laboratory, and Lecturer in Experimental Psychology, University of Cambridge, "Industrial Fatigue." W. L. Hichens (Chairman, Messrs. Cammell, Laird and Co., Ltd.) in the Chair.

Charles Ainsworth Mitchell, M.A., F.I.C., "Science and the Investigation of Crime."

John Francis Crowley, D.Sc., B.A., M.I.E.E.

William Rothenstein, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England."

William Raitt, F.C.S., Cellulose Expert to the Government of India, "Paper Pulp Supplies from India."

Sir Charles H. Bedford, LL.D., D.Sc., "Industrial (including Power) Alcohol."

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

G. C. CREELMAN, LL.D., B.S.A., Agent-General for Ontario, "Modern Agriculture."

PROF. R. S. TROUP, C.I.E., School of Forestry, University of Oxford, "Indian Timber."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock:—

January 21, February 18, March 4, April 22, May 27.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 o'clock:—

February 1, April 5, May 3.

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

A. CHASTON CHAPMAN, F.R.S., F.I.C., "Micro-Organisms and some of their Industrial Uses." Three Lectures.

Syllabus.

LECTURE I.—NOVEMBER 29.—Recent views on the mechanism of Alcoholic Fermentation. The nature of the intermediate products — Some examples of the manner in which the products of the activity of certain micro-organisms may be varied according to the conditions under which the organisms are compelled to function—The production of Glycerine on a large scale by the fermentation of Sugar—The use of Moulds for the saccharification of Starch, with special reference to the Amylo-Process for the large scale production of Alcohol.

LECTURE II.—DECEMBER 6.—Use of bacteria in the Amylo-Process for the purpose of reducing the waste of Nitrogen—Biochemical production of Citric Acid, Butyric Acid and Fumaric Acid—Manufacture of Lactic Acid and Butyric Acid by fermentation processes—Manufacture of Vinegar.

LECTURE III.—DECEMBER 13.—Bacterial production of Acetone and Butyl Alcohol—Brief references to the importance of Micro-Organisms in Agriculture, Dairying and Sewage Treatment—The utilisation of waste Distillery Liquors—Use of Yeast in the production of nitrogenous food stuffs, so called "Mineral" Yeast—Need for the extended study of Industrial Microbiology in this country, and desirability of establishing a National Institute devoted to that subject.

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures. February 14, 21 and 28.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.C., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

HOWARD LECTURES.

ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E., "Aero Engines." Three Lectures. January 17, 24, 31.

JUVENILE LECTURE.

Thursday afternoon, January 6, 1921, at 3 o'clock:—

SIR FREDERICK BRIDGE, C.V.O., M.A., Mus. Doc., Emeritus Organist, Westminster Abbey, "The Cries of London which Children heard in Shakespeare's Time" (with musical illustrations).

MEETINGS FOR THE ENSUING WEEK.*

MONDAY, NOVEMBER 29 .. Transport, Institute of, at the Institution of Civil Engineers, Great George Street, S.W. Mr. E. S. Shrapnell-Smith, "Economics and Co-ordination of Transport by Road."

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C., 5 p.m. Presidential Address by Sir Alfred Watson.

WEDNESDAY DECEMBER 1 .. Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m.

United Service Institution, Whitehall, S. W., 5.30 p.m. Major-General B. F. Burnett-Hitchcock, "Man Power."

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Dr. A. C. Fryer, "Monumental Effigies sculptured by Nicholas Stone: Part II. Additional Notes on Seven-Sacrament Fonts."

Sanitary Engineers, Institute of, 296, Vauxhall Bridge Road, S.W., 6 p.m. Mr. W. H. Makepeace, "Activated Sludge Disposal."

THURSDAY, DECEMBER 2 .. Aeronautical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 8 p.m. Major Scott, "Airship Piloting."

Pottery and Glass Trades Benevolent Institution, at the Royal Society of Arts, John Street, Adelphi, W.C., 8 p.m. Mr. H. Barnard, "The Decorating of Pottery and Porcelain."

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace Road, S.W., 6 p.m. Dr. W. Brown, "The Value of Suggestion in Education."

FRIDAY, DECEMBER 3 .. Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Discussion on Mr. A. Ramsay's paper, "The Human Factor in Industry."

*For Meetings of the Royal Society of Arts see page 1.

Journal of the Royal Society of Arts.

No. 3,550. VOL. LXIX.

FRIDAY, DECEMBER 3, 1920.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

TUESDAY, DECEMBER 7TH, at 4.30 p.m. (Colonial Section.) A. H. ASHBOLT, Agent-General for Tasmania, "The Trade of Australia during and after the War." The Rt. Hon. Sir WILLIAM ELLISON-MACARTNEY, K.C.M.G., in the Chair.

WEDNESDAY, DECEMBER 8TH, at 4.30 p.m. (Ordinary Meeting.) E. A. BRAYLEY HODGETTS, Chairman, Russian Section, London Chamber of Commerce, "A Retrospect of the Personal Influence of Britons in Russia." The Rt. Hon. Lord CARNOCK, G.C.B., G.C.M.G., G.C.V.O., K.C.I.E., Ambassador to Russia, 1906-10, in the Chair.

Further particulars of the Society's meetings will be found at the end of this number.

CHANGE OF DATES OF CANTOR LECTURES.

At the first lecture of the course on "Micro-Organisms and some of their Industrial Uses," by Mr. A. Chaston Chapman, F.R.S., held on November 29th, it was found that many of the audience desire to attend the meeting of the Society of Chemical Industry on Monday, December 6th, at 8 p.m., when Dr. Herbert Levinstein will deliver an address on "The Dyestuff Industry." It was, therefore, decided that Mr. Chaston Chapman's second lecture should be delivered on Monday, December 13th, and the third lecture on Monday, December 20th, instead of the dates previously announced.

EXTRA MEETING.

An extra meeting of the Society will be held on Friday, December 17th, when a paper on "The Breeding of Sheep, Llamas and Alpacas in Peru, with a view to supplying improved Raw Material for the Wool and other Textile Trades," will be read by COLONEL ROBERT STORDY, C.B.E., D.S.O.

SECOND ORDINARY MEETING.

WEDNESDAY, NOVEMBER 24TH, 1920; SIR PHILIP LLOYD-GREAME, K.B.E., M.C., M.P., Parliamentary Secretary to the Board of Trade, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Attwood, Stanley Herbert, Lincoln.
Fiske, William Grant, Westcliff-on-Sea.
Hutchinson, Gerald Pemberton, London.
Kerr-Jarrett, Hon. F. M., Jamaica, B. W. Indies.
Murray, James O'Hara, M.I.Mech.E., London.
Newell, Edwin Frank, London.
Reed, Engineer-Commander William W., R.N., Portsmouth.
Scott, Robert L., Greenock, N.B.
Scott, Rev. William Stuart, Kenilworth.
Tatton, Herbert Ernest, Lincoln.
Thomas, Felix J., Woburn, Bucks.
Thomson, Robert, London.

A paper on "Colour Vision and Colour Blindness" was read by Dr. F. W. ELDRIDGE-GREEN, C.B.E., F.R.C.S., Special Examiner in Colour Vision and Eyesight to the Board of Trade.

The paper and discussion will be published in the *Journal* of December 10th.

JUVENILE LECTURE.

A lecture adapted to a juvenile audience will be delivered on Thursday afternoon, January 6th, 1921, at 3 p.m., by Sir FREDERICK BRIDGE, C.V.O., M.A., Mus. Doc., Emeritus Organist, Westminster Abbey, on "The Cries of London which Children heard in Shakespeare's Time." The lecture will be musically illustrated.

Special tickets are required for this lecture. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

PROCEEDINGS OF THE SOCIETY.

FIRST ORDINARY MEETING.

WEDNESDAY, NOVEMBER 17TH, 1920.

Mr. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

WIRELESS TELEGRAPHY AND TELEPHONY.

By ALAN A. CAMPBELL SWINTON, F.R.S., M.Inst.C.E., M.I.E.E., M.I.Mech.E., Chairman of the Council of the Society.

Your Council has done me the unusual honour of electing me as their Chairman for a third year of office, and I desire to express my appreciation of this distinction. It thus becomes my duty, once more, to deliver to you an Address on the occasion of the opening of the new Session, which is the 167th Session since the Society's inauguration. Having already given you two addresses on general subjects, and being conscious of the difficulty of giving a third one of the same character that would be of interest, I have thought it best to make a change from the general to the particular, and to give an address that could be illustrated by experiments.

The subject that I have chosen, that of Wireless Telegraphy and Telephony, shares with aerial navigation the merit of being amongst the most useful and the most startling of the recent practical applications of science. It is also a subject which, as I hope to show you this evening, lends itself to practical demonstration to a large audience such as is here assembled.

As is now well known, the transmission of wireless signals is effected by means of electric magnetic waves. Until recently, these waves were supposed to consist of periodic motions of an all-pervading hypothetical medium extending throughout the universe, known as the ether of space. Professor Einstein's recent theory of the Principle of Relativity, and the results of certain astronomical experiments made to test this theory, have thrown some doubt on the necessity for, or the existence of, the ether; but though the exact nature of these electro-magnetic waves may be questioned, there is no doubt about their existence and their effects. They travel with the velocity of light, namely, at the rate of 186,000 miles per second, and appear, indeed, to be exactly similar to what we call light, except as regards their wavelength and as regards the frequency of their vibration. Whereas the waves of visible light have a length to be measured in millionths of a millimeter, and a frequency of billions per second, the waves used in wireless are seldom less than 100 meters in length, and may be as long as 20,000 meters or more. At the same time, their frequency is to be reckoned in millions down to thousands per second. Nowadays, everywhere, at all times, in this very hall, at this present moment, all space is permeated with these wireless waves, actuated by human intelligence, and conveying human thought. Some, comparatively large in amplitude, come from our own and other European countries; others, weakened by expansion over long distances, reach us from America, Africa, Asia, and even from Australia. In a greater or lesser degree of attenuation probably all of them reach us, though it is only the stronger ones that at present can be made to register their existence with sufficient exactness to deliver the messages that are the reason for their dispatch. These waves pass through brick walls, and through wood, glass, slate and plaster roofs and ceilings, practically without loss. As Lovelace wrote—"Stone walls do not a prison make, nor iron bars a cage;" but, curiously enough, though for wireless waves the first of these famous lines holds good, this is not correct as regards the second line, for these waves cannot easily escape from or penetrate into enclosures that are surrounded by metallic conductors, even though the interstices are of considerable size. Consequently, though the waves can pass freely into the interior of a room, such as the one in which you are seated, in the construction of which little or no metal has been employed—and it makes no appreciable difference whether doors or windows are open or shut—they do not readily obtain access into buildings constructed of ferro-concrete, or with steel framing, or through roofs of copper, lead or galvanised iron. Into the interior of an iron safe or a copper or a tin box, in which there were no slits or holes, I fancy they would not penetrate at all.

So far as is known, these waves, even the strongest of them, have no direct effect on any of the five senses which are the sole avenues whereby we appreciate anything that is external to ourselves. Directly, we can neither feel, hear, smell, taste or

see them. True, the eye is a detector of electro-magnetic waves such as light consists of, but the unaided eye can only detect the very short waves of visible light which, as already mentioned, are minutely short and are all contained within the narrow limits of a single octave, and though by means of fluorescence and such like phenomena the range of visibility can to some extent be increased, no such method will render visible even the shortest of the waves used in wireless. Other methods have therefore to be adopted, and those hitherto used all consist of means whereby the received electro-magnetic waves are employed to generate electric currents or to cause variations in otherwise constant electric currents to an extent that, with the delicate instruments employed, is capable of observation. A Wireless receiving station is, therefore, a kind of artificial eye, looking out into space and detecting and rendering either visible or audible to human eyes or ears, or perhaps even recording on paper, the signals that the received electro-magnetic waves convey. All the older stations comprised a wire aerial raised on masts, high above the earth, this aerial being connected to the earth through coils and condensers whose inductance and capacities tuned the whole apparatus so as to make it resonate to the incoming waves. As detectors, Lodge, Marconi, and the early experimenters, used coherers, until these were superseded by the more sensitive crystal detectors. Now to-day, both for detecting the waves and for amplifying the currents, that wonderful piece of apparatus, the thermionic tube, has practically superseded everything else, and has rendered high aerials no longer necessary for receiving, though they are still used in many cases and are still necessary for transmitting over any considerable distance.

We have a small aerial of about 100 feet in length reaching from this lecture table to above the roof of the building, and I can connect this with the receiving apparatus on the table, which consists of a variable inductance, an adjustable tuning condenser and a number of thermionic valve tubes arranged in cascade.

On some wavelength or other– and I can vary the adjustments to receive different lengths—we are pretty certain at all hours of the day and night to receive signals. Indeed, when we adjust the apparatus to suit 600-meter waves, we shall probably receive a number of different messages at once, which may not be easy to disentangle from one another. This is for the reason that 600 meters is the wavelength employed in the mercantile marine, and we thus get all the ships in the Thames, in the Channel, or round the neighbouring coasts, which may happen to be sending, as well as the coast stations at the North Foreland, Dover, Harwich, Havre, Dunkirk, Scheveningen, etc. All these are what is known as spark stations, in which the waves are generated by electric oscillations caused by sparks, and where the note heard in the receiving telephone is dependent upon the number of sparks per second in the transmitter.

Another system, and one that is coming more and more into use, is that which employs what are known as continuous waves, that is to say, waves that maintain a constant amplitude throughout the sending of a signal, such as a dot or a dash of the Morse alphabet, and do not vary in amplitude several times from maximum to zero during even a single dot, as is the case in spark transmission. Such continuous waves are, of course, mostly of far too high a frequency to give a direct audible effect, even if the telephones could respond to such rapidly varying currents, which they cannot. The frequency of any but the very longest of these waves runs into figures of 50,000 to say 500,000 per second, while the highest note audible to the average human ear has a frequency below 40,000. In order to render audible the signals sent by these continuous waves, a very beautiful and ingenious method called "heterodyning" is used. This is based on the well-known acoustical phenomenon of beats. Two different notes having different frequencies, produce a third note due to the difference between the frequencies of the first two notes. In this way by producing locally at the receiving station an electrical oscillation only slightly differing in frequency from the frequency of the incoming signal, an audible note is obtained, and by varying the frequency of the local oscillation the audible note can be made of any convenient pitch, though alone either of the primary oscillations is of much too high a frequency to give any audible effect whatever. This method gives great selectivity, and enables several simultaneous incoming signals of only slightly different wave length to be

distinguished from one another with marvellous nicety.

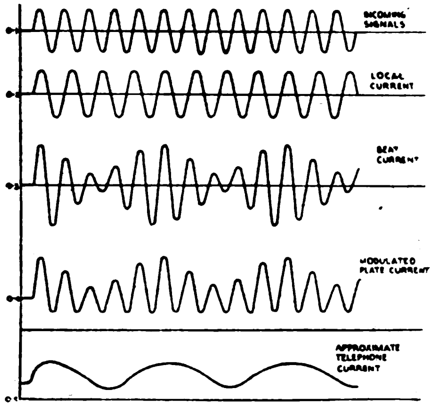

FIG. 1.
CURVES ILLUSTRATING HETERODYNE RECEPTION.

Fig. 1 shows diagrammatically the different stages of heterodyne reception. The top curve represents the incoming signals of too high a frequency to be audible. The second curve shows the local current, also of too great frequency to be heard, but of a slightly different frequency from that of the signals. The third curve shows the resultant beat current, while the fourth is this beat current after it has been rectified. Finally, the bottom curve shows the variations in the current caused to pass through the telephones, these variations being of a frequency much lower than that of the incoming signals, and one that can readily be heard.

I will now describe some of the apparatus that we are going to use. Fig. 2 represents diagrammatically an amplifier containing seven thermionic tubes arranged in cascade, so as to magnify the received signals many thousands of times. Each thermionic tube or valve, as it is called, consists of a glass bulb exhausted to a very high degree of vacuum. Inside each bulb there are three electrodes, insulated from one another, but with terminals connected to them sealed through the glass walls of the bulb. The first of these electrodes is a filament of tungsten, just like the filament of an incandescent electric lamp, and, as will be observed, the filaments of all the seven valves are connected through a regulating rheostat to a 4-volt battery by which the filaments can be caused to become incandescent. Then, above the filament in each bulb there is shown, by the dotted line, another electrode which is called the grid. In some forms of valves it is actually a grid made of fine wire netting, and hence its name; but in the actual valves I am using, it in fact consists of a small spiral of wire surrounding but not touching the filament, which is straight. Then there is a third electrode, shown by the thick black line at the top of each bulb, called the plate, which, in the type of valve we are using to-night, takes the shape of a metal cylinder fixed outside the spiral that forms the grid, without touching either the grid or the filament. Further, connected between the filament and the plate of each valve there is connected, as you will observe, a battery giving about 80 volts, the negative pole of which is coupled to the filament. Now, under these conditions, when we cause the filaments to glow, there is an emission of negative ions across the vacuous space between each filament and each plate, which emission is equivalent to an electric current. But, for the negative ions to get from the filament to the plate, they have to pass through the interstices of the grid, and it is found that the electrical condition of the grid has an enormous influence on the amount of

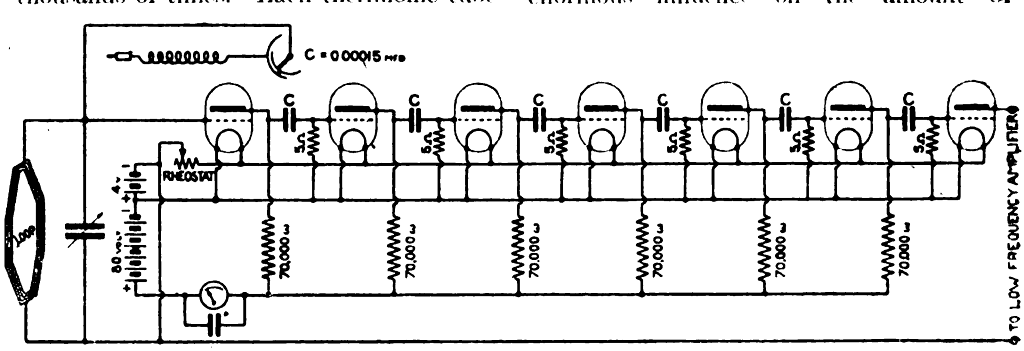

FIG. 2.
SEVEN VALVE RESISTANCE AMPLIFIER.

electricity that passes. If the grid is made positive it attracts the ions and assists the passage of the electric current; if it is made negative it repels the ions back on to the filament, and the strength of the electric current is reduced. The whole of modern wireless telegraphy is dependent upon this effect, which consists in the fact that very small electric charges applied to the grid enormously vary the negative current that flows from the filament to the plate.

Then, as you will notice, the plate of one valve is connected through a small condenser to the grid of the next, and so on throughout the whole series. This is called connecting in cascade, and has the effect of causing each succeeding valve to multiply the variation in the current passing through the one behind it. The result is that the amount of magnification increases very rapidly with the number of valves you employ.

As will be observed, on the extreme left of Fig. 2 is shown a coil or loop of wire, the one end of which is connected to the grid of the first valve, and the other to all the filaments, as also to the "out" terminal of the instrument. Across the two ends of the loop there is also connected a variable condenser. This loop, or frame aerial as it is also called, merely consists of a coil of copper wire of some 30 to 100 turns, and about a yard in diameter, placed with its plane vertical to the ground. With such a loop when suitably tuned by means of the variable condenser, the waves from all the larger European wireless stations can be picked up inside a room like this with sufficient efficiency to operate an amplifier such as the one before you. Moreover, such a loop is directional, as, in order to get the strongest effect with it, it must be placed so that its plane passes through the sending station. Indeed, if turned at right angles to this position, the effect on the two sides of the loop is equal and opposite, and the signals die away altogether.

In this way, with such a loop, the direction of the sending station can be located within a few degrees. To-night, however, we are not going to operate with a loop, but with a small aerial that we have set up upon the roof of the building. This aerial will be connected to the amplifier through a variable inductance, so that we may be able to tune it to the wave length of the signals that we want to receive.

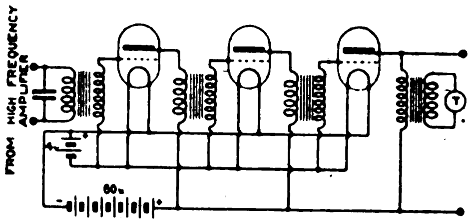

Fig. 3.

Three Valve Note Magnifier.

I have still to explain the purpose of the small adjustable condenser shown on the left-hand side at the top of Fig. 2. As will be observed, one plate of this condenser is connected to the grid of the first valve, while the other plate is connected to a loose plug at the end of a flexible wire. Now, this plug can be inserted in any one of six sockets connected with the plates of the six last valves, and the whole arrangement is for the purpose of causing the valves to set themselves into a state of oscillation in order to receive a continuous-wave station by the system of heterodyning that I have already explained to you.

We will now pass on to Fig. 3, which shows a further amplifier, or note magnifier as it is sometimes called, which is connected to the "out" terminals of the seven-valve amplifier. This note magnifier serves to magnify still further the signals. It has three valves, but, as will be observed, the connection between the valves is not through condensers as in the 7-valve amplifier but through small transformers with iron cores.

On the extreme right of this note magnifier is shown the receiving telephone "T," as also two terminals to which the recording and printing apparatus, to which I am coming shortly, can be connected.

In an Address that I gave to the Wireless Society of London before the war, as long ago as January, 1914, I suggested that before long we might have a "wireless operated column printing telegraph machine in every house, telling the latest news to all the nation, as also to the newspapers, should any of these continue to survive the competition of this much more rapid method of disseminating intelligence," and in the Address I gave to this Society---The Royal Society of Arts—in November, 1918, I enlarged upon the idea, pointing out that it ought now to be quite practicable to operate wirelessly the telegraph printing machines, which have for

long been familiar objects in London Clubs and Hotels. Further that as no connecting wires would be required, there would be a great saving both in first cost and in the expense of upkeep, and that as in wireless telegraphy it costs no more to send signals to a thousand receiving stations than to a single station, there is practically no limit to the number of stations that can simultaneously receive signals from a single transmitting station. In conclusion I said, "To some, this sketch of the universal distribution of news to all and sundry may appear fantastic, but it is not really so at all; for at any rate as concerns an area no larger than Western Europe and the British Islands, it is well within the range of practicability at the present time, and only requires a little working out to arrive at the best arrangements."

To-night, I want to bring to your notice a further stage in the development of this idea, and to demonstrate to you by actual experiment how a telegraph instrument printing the messages it receives on paper in ordinary Roman type can be operated by wireless means from places as distant as Paris and Portsmouth. The wonderful instrument with which I hope to show you how this can be done was invented some years ago by Mr. F. G. Creed, of Croydon, and is in regular use on wires between London and Glasgow, London and Edinburgh, London and Manchester, and elsewhere, for newspaper use. It has been in use on wires for some considerable time, but it is only recently that it has been adapted to wireless transmission, and to-night is, I believe, the first occasion on which the printing in Roman type of wireless messages has been demonstrated in public. Mr. Creed's apparatus consists of two machines, the receiver and the printer. The first of these takes the Morse signals from a telegraph line, or, in our case to-night, from our wireless amplifiers, and records them by punching small holes in a moving strip of paper tape. This tape is then passed through the printer, which automatically converts the Morse signals into the appropriate Roman characters and prints them on a second paper tape.

Fig. 4 will help to explain this. At the top are Morse signals giving the signature of the Eiffel Tower—the letters F L—twice repeated in dot and dash.

Below this are the same signals as punched on paper tape by the Creed receiver. The very small holes along the centre of the tape are merely for the purpose of ensuring the regular motion of the tape, and have nothing to do with the signals, which are denoted by the larger holes near the edges. As will be seen by comparison with the Morse signals above, when two holes are vertically above one another, this denotes a dot; when the two corresponding holes are inclined to one another, they represent a dash.

At the bottom of the Figure are the letters F L printed by the Creed printer from the tape above it. These particular letters were printed from Paris a few days ago.

Fig. 5 gives a general view of the Creed receiver and printer, which are driven by electric motors which assist to operate the mechanism, besides supplying the compressed air that is employed in the working.

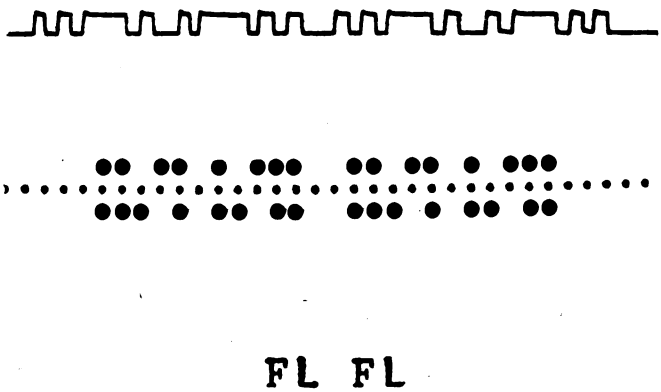

FIG. 4.
MORSE SIGNALS, PUNCHED TAPE AND CORRESPONDING ROMAN TYPE.

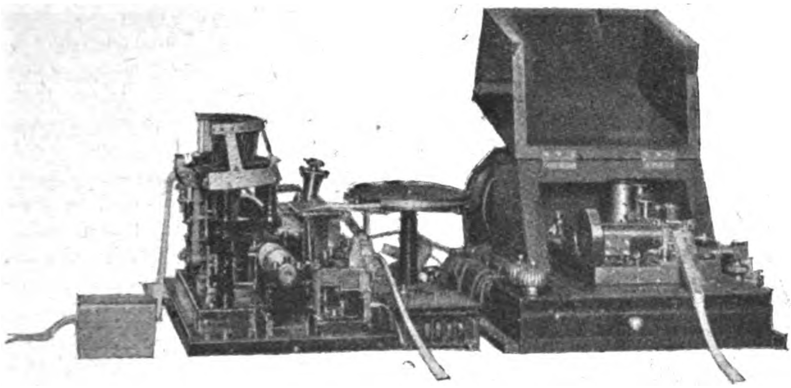

FIG. 5.
GENERAL VIEW OF CREED PRINTER AND RECEIVER.

The Fig. 6 shows in diagrammatic form the construction of the receiver. "A" represents a special relay invented by Mr. Rupert Carpenter of the Creed Co. This relay has no electrical contacts, but its armature "b" is provided with a light tongue "1," to the free end of which is attached an exceedingly light balanced slide valve "2;" this is adapted to control the supply of air to the small relay engine

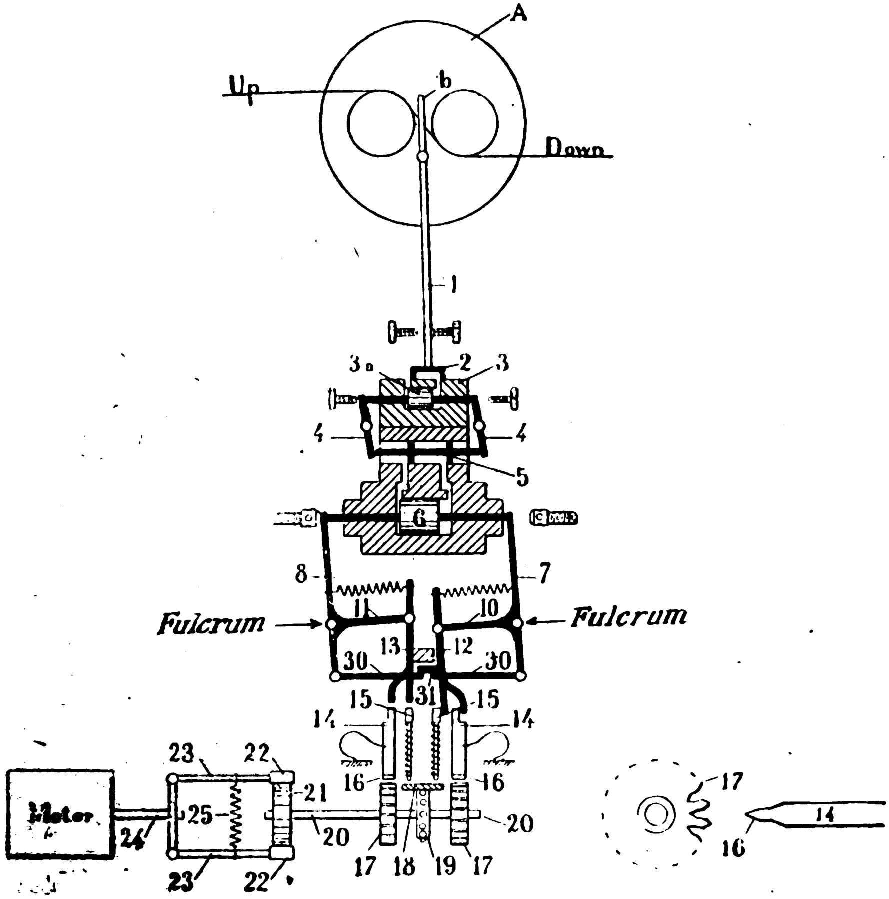

FIG. 6.
DIAGRAM ILLUSTRATING THE CREED RECEIVER.

"3," the piston "3a" of which is thus moved from side to side, in accordance with the Morse signals which actuate the relay tongue and are received through a second relay, from the wireless amplifiers. The movements of the piston "3a" are transmitted by means of the rocking levers "4" to the piston valve "5" of the main engine, thus controlling the double-acting piston "6." From each side of this piston a rod projects through the cylinder cover and thrusts in either direction the adjacent arms of the three-armed bell-crank levers "7" and "8." Upon the arms "10" and "11" are hard steel strikers "12" and "13," the free ends of which are bifurcated for the purpose of thrusting against the adjacent heads of the rods "14" and punches "15." These rods and punches are mounted and guided in a separate block, with the die plates and the feed wheel spindle. The correcting rods "14" have flattened points "16," terminating in a V-shape (shown separately), and when thrust forward are adapted to enter the slots in the correcting wheels "17." Retracting springs are provided, as shown, to restore the rods and punches to their normal position against stops. The paper strip "18," which is previously centre-holed, is led up between the die plates, past the punches, and engages with the feed wheel "19," mounted upon the spindle "20," to which the correcting wheels "17" are also fixed. When the points "16" of any connecting rod "14" are thrust by the striker between the teeth of the wheel "17," the rod adjusts and holds the latter, as well as the feed wheel "19," and the tape, in such a position that the corresponding punch "15" will perforate the paper exactly opposite the feed holes. Mounted upon an extension of spindle "20" is a friction disc "21," driven by the friction blocks "22," fixed upon the pivoted arms "23," which are attached to the motor-driven spindle "24." This spindle rotates the feed wheel "19" at approximately the same rate as the feed wheel of the transmitter. For adjusting the driving tension the spring "25" is arranged to slide longitudinally on the rods "23."

The action of the machine is as follows: A line "marking" current in the relay coils moves the armature "b" to the right, causing the tongue "1" to move the valve sharply to the left. The piston "3a" of the relay engine is thus caused to move to the right, and the valve of the main engine in the opposite direction. This causes the main piston to be driven to the right. The movement is transmitted by means of the bell-crank "7" and the link "30" to the bell-crank "8," which in turn causes the left-hand striker "13" to thrust the tooth of rod "14" between the teeth of the wheel "17," adjusting, if necessary, the position of the feed wheel, and forcing the corresponding punch "15" through the tape "18." The tappet piece "31" formed on the link "30" now comes in contact with the striker, forcing it from the rod and punch, and permitting them to spring back to their normal position. On the reversal of the line current the relay tongue is moved in the opposite direction, causing a reversal of the engine, when another operation similar to that described is performed by the right-hand striker "12" upon the right-hand correcting rod and punch.

As the complete operation of thrusting and releasing the punches occupies only the 300th part of a second, the time during which the feed wheel is arrested is practically negligible, and the difference between dots and dashes in the tape depends entirely, therefore, upon the time-interval between successive spacing and marking contacts during which the tape is allowed to run on. Even between the marking and spacing currents for a dot, there is an appreciable interval during which the slip has travelled a little. The right-hand punch, and the corresponding correcting wheel, are given a lead, so that, although the spacing punch is actuated later, the spacing perforation appears opposite the same centre-hole as the marking perforation.

A diagrammatic explanation of the action of the Creed Printer is shown in Fig. 7.

The received perforated slip is passed into the machine at "A" and out at "B;" while the slip on which the printing takes place is drawn by a pair of feed-rollers from the roll on the upper left-hand side, between the connecting rods of the type-bars and over the printing platen.

The perforated tape is fed forward letter by letter in a guide-way in front of a series of ten pairs of selecting needles, one needle of each pair being mechanically connected to a series of ten slide-valve plates. Each of these valve plates can be made to occupy one of two positions, thus providing a number of different combinations, every

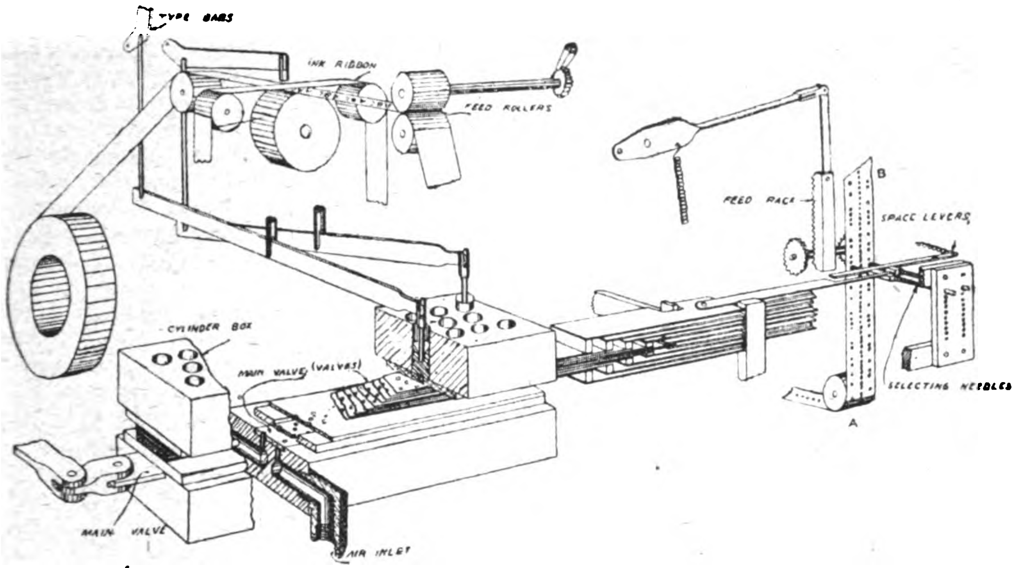

FIG. 7.
DIAGRAM ILLUSTRATING THE CREED PRINTER.

one of which opens one complete and particular passage through the ten slide-valve plates. Air under pressure can thus be admitted to any one of a number of small cylinders, each containing a piston acting on the end of a lever connected to a type bar, there being just as many cylinders as there are different characters and figures to be printed.

The perforated slip is fed forward by a star wheel fitted to a spindle carrying a toothed wheel, which is rotated as required by the movement of a rack. The rack is given a vertical motion for feeding purposes, and a sidewise motion for acting on any slide valves that may have been selected. Its movement is obtained from the camshaft of the machine, which is belt-driven from a small electric motor. The extent of the vertical movement is limited by the distance to the first space signal, that is to say, the length of a letter. To provide for this limit there is a group of ten space levers normally in the path of the rack, and preventing its downward movement. Each space-lever is also in the path of one pair of selecting needles, and when either needle of a pair passes through a perforation, that space-lever is moved out of the path of the rack. Hence, with any letter or figure of the International Morse Code there is a clear downward path for the feed-rack until it reaches a space signal. A sidewise movement is then given to the rack, putting it in gear with the toothed wheel. Next, the rack is given an upward motion, causing the toothed wheel to turn and the perforated tape to be fed upward by the amount of the particular letter that has just passed. The rack is then moved sideways again, clear of the toothed wheel, ready to descend as far as the next space signal.

The slide valves, made of thin sheet-steel, have each a hinged extension whose further end is arranged to take up the movement of the corresponding selecting needle in its motion to and from the perforated tape. At the same time, the extension is free to move in a direction at right-angles to the needle. Each valve-extension is provided with a shoulder which comes into the sidewise path of the feed rack when that particular extension has been selected. At the correct moment, determined by the position of a cam on the main spindle, the rack is moved sidewise, and engaging with the shoulders of the valve extensions which have been selected, moves the corresponding slide-valves into their second position. Another cam opens a main valve, admitting air under pressure to the slide-valve chamber, whence it passes through the ten valve plates by the one hole available in that particular setting of the valves, forces up the particular piston and prints the corresponding letter. Another main valve is then opened to allow the air to escape, and the selected slide

valves are returned to their normal position.

Although more than the required number of selecting needles for any particular letter may pass through the tape, only the proper number of slide valves are acted upon by the rack, on account of the spacing lever preventing the rack descending beyond the required amount.

It will be observed that there are 20 selecting needles, but only the 10 acting on the lower row of holes in the perforated slip are attached to valves; the other row of needles is not necessary for selecting purposes, but is required for shifting the spacing levers for the first portion of a dash signal. This instrument is by no means easy either to explain or to understand, but in its main features it is not unlike an ordinary typewriter in which the printing levers, instead of being actuated by the fingers of an individual, are each connected with the piston of a separate small pneumatic cylinder. There are as many cylinders and pistons as there are characters to be printed, and the wonderful part of the mechanism is that whereby the cylinder connected with any particular letter that has to be printed is connected to the air supply at the right moment.

This is effected by the sliding perforated plates which constitute a very elaborate form of multiplex slide-valve controlling the access of air to the whole of the cylinders, but admitting the pressure to only one cylinder at a time. The motion of these sliding plates is in turn controlled by the little pins which are all the time feeling for the holes in the perforated tape as it passes by, and working in and out of these holes. It is a very remarkable arrangement for it is an apparatus with a memory. For instance if three dots come along on the tape, it prints the letter "S." If, however, it gets a further signal beyond these three dots, it has to remember these three dots while it is waiting to see what is the nature of the additional signal. If the latter is a fourth dot, it then prints the letter "H," but if the last signal is a dash then it prints the letter "V." Thus for any letter or figure that is denoted in the Morse alphabet by more than a single signal the machine has got to remember the nature of all the signals it has accumulated for that particular letter, before it knows what letter to print.

Having now described to you all the instruments that we are going to use in this demonstration of printing by wireless telegraphy, we will pass on to the actual operation of the whole apparatus. We propose to begin by receiving a wireless emission that is sent out every evening from the Admiralty station at Horsea, near Portsmouth, just about 60 miles from London. This station sends out general news between 8 and 8:30 every evening, using 7000 metre continuous waves generated by thermionic valves. The power employed is, I understand, about 35 kilowatts, and the signals can be read all over Europe, and even as far as Cairo. As the emission is, as I have stated, a continuous wave one, we shall have to make our amplifier valves oscillate so as to receive by heterodyne, and then by adjusting the condenser we can get the signals on any musical note we prefer.

As you can hear, Horsea is now sending, but we are being "jammed" by some other station, whom however, with a little adjustment we can tune out. We will now make the signals as loud as possible and turn them on to Mr. Creed's receiver, which will record them by punching the tape, which it is now doing. It may interest you to know that the emission from Horsea is sent automatically by means of punched tape, and what the Creed receiver is now doing is to make an exact facsimile in this room, of the tape that is simultaneously being used at Horsea for sending the message.

Having now received as much of the message as is necessary to show the working of the apparatus we will stop receiving and pass the tape that has been punched, through the Creed printer. It is now being printed in Roman type, and when we have printed a short passage, we will pass the printed tape through the optical lantern so that you can see the words and letters projected on the screen.

As you will observe, this portion of the message conveys Mr. Bonar Law's views as to the responsibility of governments under treaties.

It is now nearly a quarter to nine o'clock, when, by the kindness of General Ferrié, who is the head of the French Military Wireless Administration, the Eiffel Tower are going to send us a special message. They will send on a 2,600 meter wave, and as they will use spark transmission we shall not require to employ heterodyne reception. They also will send automatically by means of punched tape, and in the first instance

they are going to send the word "Paris" repeated a number of times in order that we may get our instruments here properly tuned up, after which they will send their special message.

As you hear, the Eiffel Tower is now sending and is being recorded on the Creed receiver. We will let it continue until it is finished, then print it with the Creed printer and project the printed tape on to the screen as we did with the message from Horsea.

As you will observe, the message is as follows:— "FL FL. This message is sent by permission of General Férrié by automatic perforated tape wireless transmitter from the Eiffel Tower Paris for the purpose of being recorded on a Creed Type-printing receiver at a meeting of the Royal Society of Arts on the occasion of an address on Wireless Telegraphy by Mr. A. A. Campbell Swinton, November, 1920. FL FL"

Fig. 8 shows a reproduction in facsimile of a portion of the tape as automatically printed in the lecture hall.

We will now pass on to another and entirely different branch of my subject, namely, Wireless Telephony, of which we hope to show you a practical demonstration from a private wireless station at a distance from this hall.

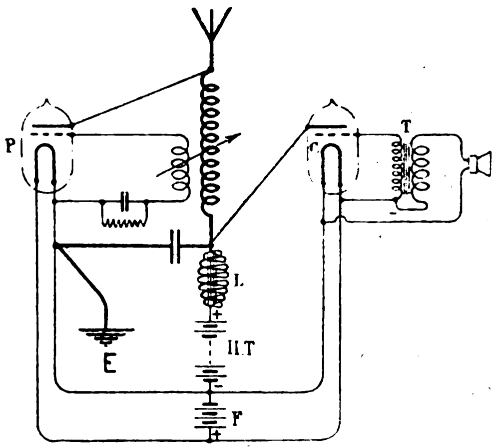

FIG. 9.
WIRELESS TELEPHONIC TRANSMITTER.

order to produce the necessary electromagnetic waves we employ two oscillating thermionic valves very similar to those that I have described to you in connection with receiving amplifiers. In the figure "P" is the power valve, while "C" is the control valve connected with the telephonic microphone on the right through the transformer "T."

The aerial is shown at the top of the figure and it will be seen that the plate electrodes of both valves draw their high-tension supply of electricity through the choking

FROM THE EIFFEL TOWER PARIS

RECORDED ON A CREED TYPE-PRINTING

RECEIVER AT A MEETINM

OF THE ROYAL SOCIETY OF ARTS

FIG. 8.
FACSIMILE REPRODUCTION OF PORTION OF MESSAGE RECEIVED FROM PARIS, AS AUTOMATICALLY PRINTED.

In doing this we are restricted by the regulations under which the authorities limit unofficial wireless transmission to the very short wave length of 180 meters and the exceedingly small power of 10 watts. These restrictions add greatly to the difficulty of getting good results, but we will see what we can do.

Fig. 9 shows diagrammatically the connections at the transmitting station. In

coil "L" from the 400-volt dry battery "HT," while the 6-volt accumulator "F" supplies current for the filaments. The whole arrangement is one of the forms of wireless telephone transmitter employed by the Royal Air Force.

Coming now to the receiving apparatus in this room, we are going to employ a short-wavelength 5-valve amplifier which has been made for me by Mr. Sullivan,

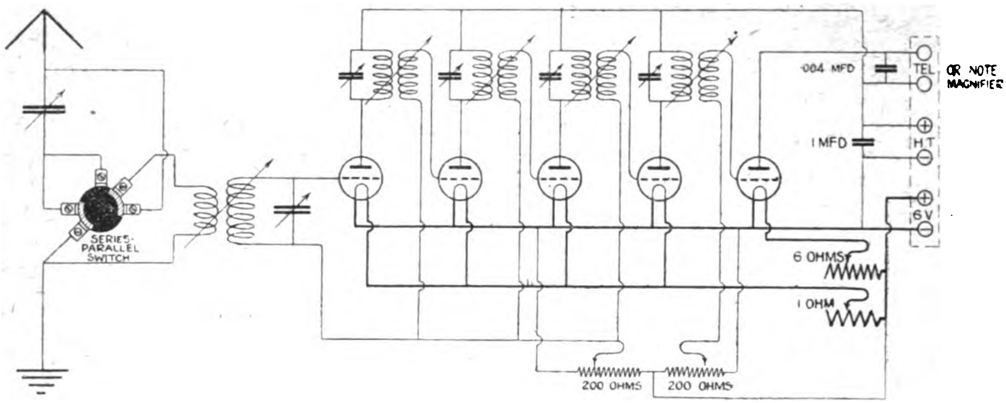

FIG. 10.
SULLIVAN SHORT WAVE RECEIVER AND AMPLIFIER

specially for this meeting. The connections are shown in Fig. 10, and as you will observe, the connection between the adjacent valves is made by means of transformers, as was the case in the 3-valve amplifier that I have previously described. In this case, however, the transformers have no iron cores, and are specially designed to suit the short wave length. In addition, the primary of each of these transformers is fitted with a separate adjustable condenser by which it can individually be tuned. There are also two potentiometers for the purpose of regulating the grid voltage on the last two valves, while the current through the filaments of the first four valves can be regulated separately from that through the filament of the last valve.

In connection with the aerial on the left-hand side of the figure there is a series-parallel switch by which the primary tuning condenser can be put either in parallel with, or in series with, the aerial.

We will now put this apparatus into use, and you will see that, owing to the very short wave length to which it is tuned, and the fact that there is nobody else sending at present on that wave length, we have much less interference than in our previous experiments.

(A demonstration of Wireless Telephony was then given, several messages being received and made audible to the audience. In addition, there were two recitations from "Mary had a little Lamb" and "The Village Blacksmith," with an exhibition of wireless whistling. Finally, some music from a gramophone was received.)

With regard to the wireless transmission of speech and music such as you have just heard, I should like to say that while it is not difficult to get speech and music very distinctly reproduced in a telephone receiver such as you hold to your ear, it is by no means easy to magnify such sounds so as to make them loud enough to be heard distinctly all over a room such as this. With present arrangements, much magnification almost invariably leads to deterioration in the quality of the sounds, and particularly in the distinctness of the articulation. Here, then, I think there is great room for further investigation and improvement, so that large audiences may be able to hear the spoken word from a distance, wirelessly conveyed, with the same ease as were the speaker actually present in the room. For such a purpose instruments such as the Parsons Auxetophone and the very loud-speaking telephonic apparatus of the Western Electric Co. are arrangements which I think might be adapted to wireless telephonic transmission.

The Western Electric Company's apparatus consists of a large-scale amplifier on the thermionic principle, coupled with an electro-magnetic telephone of very special design in which unusual pains have been taken to avoid effects due to acoustical resonance. The results obtained with this instrument with wire-telegraphy are very remarkable, as is instanced by the fact that, on the occasion of the Peace celebrations in New York, a number of these machines suspended over Broadway made plain to all the passers by in that great thoroughfare speeches that were spoken into the transmitting microphone.

In this arrangement, the magnification of telephonic articulate speech sent by wire has reached its zenith, but so far, this system has, as I understand, not been adapted to

wireless telephony, at any rate in this country.

The Auxetophone, invented by Sir Charles Parsons of Steam Turbine fame, and a member of the Council of this Society, is quite different, inasmuch as it operates by the use of compressed air. This latter is allowed to escape into a trumpet-shaped orifice of large dimensions through a very special valve of grid description controlled by the vocal vibration. This grid valve is so designed that very small movements cause great changes in the dimensions of the aperture through which the air can pass, with the result that, when the valve is controlled by the movements of a gramaphone needle or of a violin string, the resultant sounds are very loud. It is obvious that were the valve controlled by the armature of a magnet receiving telephonic currents, transmitted either by wire or wireless methods, the apparatus should work; but so far as I know, nothing has yet been done in this direction, which seems to be a very promising field for research.

The Parsons Auxetophone is, indeed, an instrument that so far has, so to speak, missed fire. Its inventor is so eminent in other fields, that he has not troubled to push it to the extent that might have been done. It is, however, a very remarkable invention, and has many possible applications, amongst which is, I am sure, its adaptability to the magnification of speech and music wirelessly transmitted from a distance.

Anyway, however exactly it may be brought about, I have little doubt that, with further experiment, it will eventually be found possible to reproduce wirelessly transmitted speech with sufficient loudness and sufficient fidelity to the original, that verbal oratory will no longer be confined, as at present, to single rooms or halls. Thus, individual speakers will be able to address an unlimited number of audiences simultaneously. Indeed, at election times, we shall doubtless, before long, see the great party leaders addressing hundreds or may be thousands of separate meetings distributed over the whole country, at once. Different political parties will have to be allotted different wavelengths so as to avoid a babel of opposing declamations, or the distressing possibility of an audience getting a speech of the wrong political flavour and of having perhaps the most violent Bolshevist doctrines thrust upon it just at the moment that it was expecting the enunciation of the latest conservative principles.

Finally, some day we may have the Prime Minister, or even the Monarch himself, addressing by word of mouth, and at one and the same time, all the different parts of the entire British Empire, for the wireless telephone seems destined to give us, in sooth, something equivalent to the "great voice as of a trumpet" that we read of in the Apocalypse—a voice that can be heard even to the uttermost ends of the Earth.

Before I sit down I desire to express my best thanks to those who have assisted me in connection with what I have been able to show you this evening. My special thanks are due to Mr. F. G. Creed, of Messrs. Creed and Co., Ltd., East Croydon, who has so kindly lent me a set of his wonderful telegraphic printing apparatus; also to Mr. Rupert Carpenter, of the Creed firm, who has been tireless in getting this apparatus to work. Then there is General Ferrié, one of the most obliging of men, who has, for a third time, assisted me by sending a special wireless dispatch from the Eiffel Tower for the purpose of demonstrations that I have made.

Again, I have to thank Mr. H. W. Sullivan, the well known telegraphic instrument maker, who made me up, at very short notice, the special amplifier I have used to-night for speech and musical reception.

There is also Capt. C. R. D'Arcy, of Messrs. Newton Bros. of Derby, who has very kindly lent me a special form of motor-generator giving as much as 1,000 volts continuous current, used in the speech transmission; also Mr. Horace Beck, of the well known optical firm of that name, to whom I am indebted for the projection apparatus with which I have been able to show on the screen the messages received.

Further, there is Mr. Davenport of this Society, who is always so ready to assist those showing experiments in this room.

Lastly, there are my own assistants, Mr. Sidney Langley, who has constructed a large portion of the wireless apparatus that I have used and has been indefatigable in getting it all to work, together with Mr. A. W. Langley and Mr. Bradshaw, who have also helped in arranging and in carrying out the demonstration, a work that has entailed no small amount of labour.

The HON. SIR CHARLES PARSONS, K.C.B., LL.D., D.Sc., F.R.S., in proposing a most hearty vote of thanks to Mr. Campbell Swinton, for his excellent Address, said the audience could but dimly realise the amount of trouble the Chairman must have taken in arranging, in such an admirable way, the various apparatus that had been exhibited for their instruction and edification. Mr. Campbell Swinton was no tyro at the subject, for he had dealt with small electrical forces which were not greater than the energy a fly used when he raised his feet from, or put them to, the ground. The amplifiers which had been used had magnified perhaps 10,000 fold or more the very minute current which had come from the Eiffel Tower. The Chairman was not only thoroughly familiar with exceedingly minute currents, but for more than 30 or 40 years he had dealt with very large apparatus running into thousands of horse power. He remembered that more than 30 years ago the Chairman did some work on a telephone, but unfortunately it was "jammed" by forces beyond his control, and the little company which was arranged had to be abandoned. If the Chairman's prophecy came true, that it would be possible to magnify vibrations so that they could be transmitted throughout the world without being "jammed," he was afraid many people would feel that life would scarcely be worth living!

MR. J. S. HIGHFIELD, M.Inst.C.E., M.I.E.E., in seconding the motion, said he was sure that all the audience had greatly enjoyed the demonstration which the Chairman had given. Personally he knew the trouble that was involved in arranging such apparatus, and particularly in getting it to work before an audience. The combination of mind which, on the one hand, could control and interest itself in great commercial enterprises, and, on the other hand, could put together small apparatus and give such interesting demonstrations was a very uncommon one. The future which Mr. Campbell Swinton had outlined was truly fearsome. The suggestion that one politician could deliver speeches to the whole world was terrific; but there was the great satisfaction that one man, by a single act, could stop all such speeches.

The resolution of thanks was put to the meeting by Sir Charles Parsons, and carried by acclamation; and the Chairman having briefly acknowledged the compliment, the Meeting terminated.

OBITUARY.

JAMES D. ANDERSON, M.A., Litt.D., I.C.S., Rtd.—Mr. James Drummond Anderson died at Cambridge on November 24th, at the age of sixty-eight. Educated at Cheltenham College and Rugby, he passed the Indian Civil Service Examination in 1873, and was posted to Bengal. After serving for four years as an Assistant Magistrate and Collector in that province he was transferred to Assam, of which Sir Steuart Colvin Bayley was then Chief Commissioner. Here Mr. Anderson was successively an Assistant Magistrate, Assistant Secretary to the Chief Commissioner and a Deputy Commissioner. In 1894 he returned to Bengal as a District Magistrate and retired in 1900.

Possessing marked linguistic and literary gifts, he was an indefatigable student of Bengali and the vernaculars of North-East India, being the author of vocabularies of the Tippera-Deori-Chuta and Aka languages, Kachari Folk Tales, Chittagong Proverbs, The Peoples of India (Cambridge Manuals), etc.

Since 1907 he had been University Teacher in Bengali at Cambridge. His degree of M.A. *honoris causa* was conferred in 1909. He joined the Royal Society of Arts thirteen years ago, and occasionally spoke at Indian Section meetings. He also made a number of interesting communications to the *Journal.*

GENERAL NOTES.

HYDRO - ELECTRIC ENGINEERING AT GRENOBLE.—The difficulty of finding facilities for the training of hydro-electric engineers was referred to by Professor A. H. Gibson in the paper on "British Engineering and Water-Power Development," which he read before the Society in 1919. The University of Grenoble has for many years made a special feature of instruction in water power and power transmission, and it is proposed next summer to hold, in connexion with the usual vacation courses there, a series of lectures on this subject, with visits to some of the numerous installations in the neighbourhood. The lectures will be given in such a way that those who have learnt French in a public school will be able to follow the work without difficulty. Grenoble, which is charmingly situated in the French Alps, is a centre where about half-a-million h.p. is developed or under construction. The fees for the course are low, and the P.L.M. Railway will probably arrange to give tickets from Paris to Grenoble at reduced rates for students attending vacation courses. The Committee of the Office National des Universités et Ecoles Francaises are anxious to create a liaison between British and French Technical Schools and Universtiies. The general arrangements for the proposed course are now under consideration, and further particulars can be obtained from Mr. H. Sloog, Hon. Secretary, British Bureau, Office National des Universités, Engineering Department, 45, Great Marlborough Street, W. 1.

Fine Chemicals. — The manufacture of fine chemicals is now recognised as a key industry, and of vital importance to the country in time of war. With a view to encouraging it in time of peace, the Association of British Chemical Manufacturers, 166, Piccadilly, W. 1., have published a list of fine chemicals, and of the firms from whom they can be obtained. The Association is also prepared to render every possible assistance to research chemists in obtaining any chemicals they may require.

Bee Industry in Australia.—The bee industry is an important one in Australia, and like poultry farming is ordinarily an adjunct to agricultural or dairying industries. The average annual production of honey in the past five years, according to *Commerce Reports*, has been over 5,000,000 pounds, with a production of about 90,000 pounds of beeswax. In the past year or two, however, the production of both honey and beeswax has fallen considerably below the high record of 1913, when over 8,000,000 pounds of honey was produced.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock (unless otherwise announced):—

December 8 (at 4.30 p.m.).—E. A. Brayley Hodgetts, Chairman, Russian Section, London Chamber of Commerce, "A Retrospect of the Personal Influence of Britons in Russia." The Right Hon. Lord Carnock, G.C.B., G.C.M.G., G.C.V.O., K.C.I.E., Ambassador to Russia 1906-1910, in the Chair.

December 15.—Major-General The Right Hon. Lord Lovat, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., "Forestry." The Right Hon. The Earl of Selborne, K.G., G.C.M.G., President of the Board of Agriculture 1915-1916, in the Chair.

Friday, December 17. — Colonel Robert Stordy, C.B.E., D.S.O., "The Breeding of Sheep, Llamas and Alpacas in Peru, with a view to supplying improved Raw Material for the Wool and other Textile Trades."

Colonial Section.

Tuesday afternoon, at 4.30 o'clock:—

December 7.—A. H. Ashbolt, Agent-General for Tasmania, "The Trade of Australia during and after the War."

Papers to be read after Christmas:—

Sir Marcus Samuel, Bt., "The General Position of the Oil Question."

Lawson, F. M., Assoc.M.Inst.C.E., "The Future of Works Management." Sir Robert A. Hadfield, Bt., D.Sc., D.Met., F.R.S., in the Chair.

A. F. Bailie, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World." Professor Sir John Cadman, K.C.M.G., D.Sc., in the Chair.

A. Abbott (Department of Scientific and Industrial Research), "The Origin and Development of the Research Associations Established by the Department."

Sir James P. Hinchliffe, "Research in the Wool Industry.",

Sir Herbert Jackson, K.B.E., F.R.S., "Research in Scientific Instrument Making."

William Cramp, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice.",

Charles S. Myers, M.D., Sc.D., F.R.S., Director of the Psychological Laboratory, and Lecturer in Experimental Psychology, University of Cambridge, "Industrial Fatigue." (Aldred Lecture.) W. L. Hichens (Chairman, Messrs. Cammell, Laird and Co., Ltd.) in the Chair.

Charles Ainsworth Mitchell, M.A., F.I.C., "Science and the Investigation of Crime."

John Francis Crowley, D.Sc., B.A., M.I.E.E.

William Rothenstein, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England."

William Raitt, F.C.S., Cellulose Expert to the Government of India, "Paper Pulp Supplies from India."

Sir Charles H. Bedford, LL.D., D.Sc., "Industrial (including Power) Alcohol."

William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

G. C. Creelman, LL.D., B.S.A., Agent-General forOntario, "Modern Agriculture."

Prof. R. S. Troup, C.I.E., School of Forestry, University of Oxford, "Indian Timber."

Indian Section.

Friday afternoons, at 4.30 o'clock:—

January 21, February 18, March 4, April 22, May 27.

Colonial Section.

Tuesday afternoons, at 4.30 o'clock:—

February 1, April 5, May 3.

Cantor Lectures.

Monday evenings, at 8 o'clock:—

A. Chaston Chapman, F.R.S., F.I.C., "Micro-Organisms and some of their Industrial Uses." Three Lectures.

Syllabus.

Lecture II.—December 13.—Use of bacteria in the Amylo-Process for the purpose of reducing the waste of Nitrogen—Biochemical production of Citric Acid, Butyric Acid and Fumaric Acid—Manufacture of Lactic Acid and Butyric Acid by fermentation processes—Manufacture of Vinegar.

Lecture III.—December 20.—Bacterial production of Acetone and Butyl Alcohol—Brief references to the importance of Micro-Organisms in Agriculture, Dairying and Sewage Treatment—The utilisation of waste Distillery Liquors—Use of Yeast in the production of nitrogenous food stuffs, so called "Mineral" Yeast—Need for the extended study of Industrial Microbiology in this country, and desirability of establishing a National Institute devoted to that subject.

Eric K. Rideal, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures. February 14, 21 and 28.

Major G. W. C. Kaye, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

Samuel Judd Lewis, D.Sc., F.I.C., Ph.C., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

Howard Lectures.

Alan E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E., "Aero Engines." Three Lectures. January 17, 24, 31.

Juvenile Lecture.

Thursday afternoon, January 6, 1921, at 3 o'clock:—

Sir Frederick Bridge, C.V.O., M.A., Mus. Doc., Emeritus Organist, Westminster Abbey, "The Cries of London which Children heard in Shakespeare's Time" (with musical illustrations).

MEETINGS FOR THE ENSUING WEEK.*

Monday, December 6 .. Royal Society of Edinburgh, George Street, Edinburgh, 4.30 p.m. 1. Prof. J. W. Gregory, "Cephalopoda collected in Angola." 2. Miss A. G. Mann, "Observations on the Behaviour of the Endodermis in the Secondarily Thickened Root of Dracæna fruticosa (Koch)."

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Dr. D. Anderson-Berry, "The Psychology of Man: Experimentally considered."

Farmers' Club, at the Surveyor's Institution, 12, Great George Street, S.W., 6 p.m. 1. Annual General Meeting. 2. Mr. J. C. Brown, "Arable Dairy Farming."

Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. H. Banks, "Blackpool Sea Coast Defence Works."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W. 8 p.m. Dr. H. Levinstein, "The Dyestuff Industry."

Geographical Society, 135, New Bond Street, W., 8.30 p.m. Major-General L. C. Dunsterville, "From Bagdad to the Caspian in 1918."

British Women's Patriotic League, Caxton Hall, Westminster, S.W., 3 p.m. Sir Henry Cowan, "Nationalization"

Alpine Club, 23, Savile Row, W., 8.30 p.m. Mr. N. E. Odell, "Successes and Failures in 1920."

Tuesday, December 7 .. Chadwick Public Lecture, 90, Buckingham Palace Road, S.W., 8 p.m. Mr. A. MacMorran, "Some Legal Difficulties in connection with the Provision of Water Supplies in Rural Parishes."

Sociological Society, 65, Belgrave Road, S.W., 8.15 p.m. Major Douglas, "The Mechanism of Consumer-Control."

Electrical Engineers, Institution of (N. Western Section), 17, Albert Square, Manchester, 7 p.m. "Discussion of Report on the Heating of Buried Cables."

Anthropological Institute, 50, Great Russell Street, W.C. 8.15 p.m. Mr. L. S. Palmer, "Some late Keltic Remains from a Mendip Cave."

Manchester Geological and Mining Society, 5, John Dalton Street, Manchester, 4 p.m. Messrs. R. A. Burrows and F. S. Sinnatt, "The Organisation of a Coal Research Association."

Wednesday, December 8 .. Automobile, Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. 1. Col. R. E. Crompton, "Roads and Vehicle Maintenance." 2. Mr. L. S. Palmer, "The Combustion of Napthalene Solutions." Wolverhampton Section), Talbot Hotel, Wolverhampton, 7.30 p.m. Discussion on the Features of the Motor Show.

United Service Institution, Whitehall, S.W., 5.30 p.m. Lt.-Col. P Johnson, "The Use of Tanks in Undeveloped Country."

Thursday, December 9 .. Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. Prof. J. R. Newstead, "Uganda Biology."

Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m.

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Discussion on papers by Messrs. W. B. Woodhouse and R. O. Kapp on "Distribution of Electricity."

Historical Society, 22, Russell Square, W.C., 5 p.m. Mr. F. W. X. Fincham, "Illustrations of Social History in the 15th and 16th Centuries, from Records of the Consistory Court of London."

Mathematical Society, Burlington House, W., 5.30 p.m.

Friday, December 10 .. London Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 4.30 p.m. Mr. W. Y. Lewis, "Londoners' Traffic Troubles: Their possible Solution by Continuous Systems."

Technical Inspection Association, at the Royal Society of Arts, John Street, Adelphi, W.C., 7.30 p.m.

Astronomical Society, Burlington House, 5 p.m.

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Saturday, December 11 .. Bio-Chemical Society (Bio-Chemical Department, Cambridge), 3 p.m.

*For Meetings of the Royal Society of Arts see page 23.

Journal of the Royal Society of Arts.

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FRIDAY, DECEMBER 10, 1920.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 13th, at 8 p.m. (Cantor Lecture.) A. CHASTON CHAPMAN, F.R.S., F.I.C., "Micro-Organisms and some of their Industrial Uses." Lecture II.

WEDNESDAY, DECEMBER 15th, at 8 p.m. (Ordinary Meeting.) Major-General The Right Hon. Lord LOVAT, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., "Forestry." The Right Hon. The Earl of Selborne, K.G., G.C.M.G., President of the Board of Agriculture, 1915-1916, in the Chair.

FRIDAY, DECEMBER 17th, at 8 p.m. (Extra Meeting.) Colonel ROBERT STORDY, C.B.E., D.S.O., "The Breeding of Sheep, Llamas and Alpacas in Peru, with a view to Supplying improved Raw Materials for the Textile Trades."

Further particulars of the Society's Meetings will be found at the end of this number.

THIRD ORDINARY MEETING.

WEDNESDAY, DECEMBER 1st, 1920; SIR CECIL HARCOURT SMITH, C.V.O., LL.D., Director and Secretary, Victoria and Albert Museum, in the chair.

The following Candidates were proposed for election as Fellows of the Society:—

Bray, Richard, Malaga, Spain.
Goldstone, Meyer H., Southport, Lancs.
Lamberton, Hugh Alexander, Pollokshields.
Liversidge, Ernest, Dewsbury.
Richardson, John Seagram, London.
Sharples, William Ellison, A.M.I.Mech.E., Chester.
Thompson, Errol H., B.A., Sunderland.
Ticehurst, Hugh Gorham, Bexley Heath, Kent.

The Candidates proposed at the opening meeting on November 19th, of whom a list was published in the Journal of November 26th (pp. 1 and 2), were duly elected Fellows of the Society.

A paper on "Embroidery: National Taste in relation to Trade," was read by Miss Louisa F. Pesel, President of the Embroiderers' Guild.

The paper and discussion will be published in the *Journal* of December 17th.

CANTOR LECTURES.

The Cantor Lectures on "The Decoration and Architecture of Robert Adam and Sir John Soane," by ARTHUR THOMAS BOLTON, F.R.I.B.A., F.S.A., Curator, Soane Museum, have been reprinted from the *Journal*, and the pamphlet (price 2*s.* 6*d.*) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures, which have been published separately, and are still on sale, can also be obtained on application.

CASES FOR JOURNALS.

At the request of several Fellows of the Society, cases have been made for keeping the current numbers of the *Journal*. They are in red buckram, and will hold the issues for a complete year. They may be obtained, post free, for 7*s.* 6*d.* each, on application to the Secretary.

JUVENILE LECTURE.

A lecture adapted to a juvenile audience will be delivered on Thursday afternoon, January 6th, 1921, at 3 p.m., by Sir FREDERICK BRIDGE, C.V.O., M.A., Mus. Doc., Emeritus Organist, Westminster Abbey, on "The Cries of London which Children heard in Shakespeare's Time." The lecture will be musically illustrated.

Special tickets are required for this lecture. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

PROCEEDINGS OF THE SOCIETY.

SECOND ORDINARY MEETING.

WEDNESDAY, NOVEMBER 24TH, 1920.

SIR PHILIP LLOYD-GRAEME, K.B.E., M.C., M.P., Parliamentary Secretary to the Board of Trade, in the Chair.

COLOUR VISION AND COLOUR BLINDNESS.

BY F. W. EDRIDGE-GREEN, C.B.E., M.D. F.R.C.S.,

Special Examiner in the Sight Tests to the Board of Trade.

Colour blindness is not a good term for the defect. Though in certain varieties which will be explained in detail later there is actual blindness to colour, in the ordinary varieties colours are clearly seen and seen as colours, but there is a lack of power to differentiate between them: for instance, reds are confused with greens and greens with reds. A colour-blind man picked up a red hot coal remarking as he did so, "What funny green thing is this?" He did not require an answer to his query when his fingers touched the coal. The case which first drew general attention to the subject of colour-blindness was that of Dalton, the famous chemist. After Dalton had received the gown of a doctor of civil laws at Oxford, which is scarlet, he actually wore it for several days in happy unconsciousness of the effect it produced in the street. When he was asked what the bright scarlet gown which he wore resembled, he pointed to some evergreens outside the window and said the colours were exactly similar to him. The lining of the gown which was pink he stated appeared to him sky-blue.

A soldier in the days when they wore scarlet coats took off his coat and put it on a hedge and was quite unable to find it when he wished to put it on again, though it was the most conspicuous object in the landscape to other people. Many colour-blind golfers find great difficulty in recognising the red flags on the greens at a distance.

Those who are colour-blind often first discover their defect as children by finding great difficulty in picking cherries or strawberries, because of the similarity in colour to their leaves. A colour-blind man has bought a bright green tie under the impression that he was purchasing a brown one; an artist has painted the face of a portrait green and trees red. A colour-blind man has written to me half of the letter in black ink and half in red ink, under the impression that the whole was written in black ink.

You will now be shown on the screen some pictures painted by colour-blind persons with the originals from which they were copied.

In the picture that you now see, the upper portion is the picture which it was desired to copy. The artist was then supplied with paints upon plates and selected those which appeared to him to match the picture. In the picture before you it will be noticed that the grey donkey has been painted green, the leaves of the plant are painted red, the brown hair of the children has been painted red, and the red hat of the girl has been represented by green. In the second picture you will see that in the copy the body feathers of the parrot are all green, but the wing has been painted crimson by the artist. In the next picture the green tail has been painted brown and the green tail of the cock has been painted purple. In the next picture the green leaves and stalk of the plant have been painted purple and so has the grey eagle, while the brown bird it is attacking has been painted pink.

You have now seen the glaring errors which are made by colour-blind persons, and you will probably think, as many have thought, that it must be a very easy thing to detect persons who make such errors. Though this is true in certain cases it is not so in others. In fact, I have submitted cases to experts who have quite failed to detect them, even after an hour's examination.

A musician's wife informed me that she had tested her husband again and again and was quite sure that he was not colour-blind, and that he was able to see colours as well as she could; she was only convinced when she found that he was quite unable to read any of the letters on my new Card Test. In order to make these points clear some facts of colour-blindness must be given.

Cases of colour-blindness may be divided into three classes, which are quite separate and distinct from each other, though one or more may be present in the same person. In the first class there is light as well as

colour loss. In the second class the perception of light is the same as with the normal sighted, but there is a defect in the perception of colour. In the first class certain rays are either not perceived at all or very imperfectly. Both these classes are represented by analogous conditions in the perception of sounds. The first class of the colour-blind is represented by those who are unable to hear very high or very low notes. The second class of the colour-blind is represented by those who possess what is commonly called a defective musical ear. Colour-blind individuals belonging to this class can be arranged in a series. At one end of this series are the normal sighted, and at the other end the totally colour-blind. In the third class of the colour-blind there is defective perception of colour through the fovea or central region of the retina not being normal, or supplied normally.

I have devised a spectrometer for estimating colour perception. In the focus of the instrument are two movable shutters, either of which is capable of moving across the spectrum. By means of the two shutters any given portion of the spectrum can be isolated. Each shutter is controlled by a drum graduated in wave-lengths, so that the position of the edges of the shutters can be known. We can ascertain with this instrument the exact size of portions of the spectrum which appear monochromatic and their varying size with different persons. We can also determine the limits of visibility on both sides of the spectrum, the exact size and position of the neutral region in different dichromics and the position of the most luminous portion of the spectrum. This instrument gives us a key to the colour perception of any person.

The spectrum or rainbow consists of a series of waves of light of different refrangibility, extending from the red which are the largest waves, to violet, which are the smallest. These waves are similar to those of the sea, only infinitely smaller. If a number of persons be asked to state how many definite primary colours they see in the spectrum, very different answers will be obtained. By primary colour I mean a colour which appears to be simple and not a compound of two colours. The large majority will say that they see six definite colours, red, orange, yellow, green, blue, and violet. A few will state that there are seven colours, indigo being added as a colour, being seen in the region of the blue-violet. Newton appears to have seen the spectrum in this way. Others will declare that there are only five colours in the spectrum, orange not being seen as a definite colour, but as a yellowish-red. Again others will be found who will state that there are only four definite colours, red, yellow, green, and violet. Again there are others who will state that there are only three colours in the spectrum, red, green, and violet. These describe the spectrum as red, red-green, green, green-violet and violet. Then we find others who state that there are only two colours in the spectrum, red and violet, with a neutral point in the green. This neutral division between the red and the violet may in extreme cases be so large that only the ends of the spectrum appear coloured with a large grey region between. Finally there are persons who see no colours in the spectrum, but see it as a colourless band varying in luminosity in its different parts. It will be seen therefore that we can classify the degrees of colour perception according to the number of definite colours which are seen in the spectrum. Those who see seven colours, may be called heptachromic, those who see six, hexachromic, those who see five, pentachromic, those who see four, tetrachromic, those who see three, trichromic, those who see two, dichromic, and finally the totally colour-blind.

It will be found then that we have a key to the hue perception of any person.

It might at first be thought that this classification was artificial and that some of the classes saw exactly alike, but further examination will show that this is not the case. Those who see six colours in the spectrum know that there are several varieties of green, but all these are associated by their green character, and are plainly compound and not simple colours; for instance, in yellow-green it is quite obvious that the colour is a mixture of yellow and green, and hence the term yellow-green, correctly describes it. The trichromic designate yellow as red-green and this does not correctly describe yellow for the normal sighted. The spectrum may be examined in another way, certain portions of it being isolated between two shutters. In these circumstances only a portion of red or portion of green is seen at the same time. An extraordinary fact then becomes apparent namely that large divisions of the spectrum appear monochromatic, as if they had been

painted with one brush of colour, though physically every portion of the division differs. Most normal sighted persons divide the spectrum into eighteen monochromatic divisions; those with super-normal colour perception, into twenty-five, and those with diminished colour perception a less number. For instance, those who see three colours in the spectrum generally divide it into ten monochromatic divisions. These divisions when examined by a normal sighted person appear quite wrong and to contain several colours instead of one. It is obvious that a man who sees only ten colours instead of eighteen will confuse colours which appear different to the normal-sighted. You will now see on the screen the spectrum as it appears to the different varieties of the colour-blind and pictures painted by each class, shewing the characteristic mistakes.

The picture now thrown upon the screen is the representation of a section of an eye. There is a membrane lining the back of the eye; this membrane is called the retina, and it is upon the outer layer of the retina that the images of external objects are formed. By outer layer I mean the layer of the retina which is furthest away from the front of the eye, so that light has to pass through all the other layers before it reaches the sensitive portion. This sensitive layer consists of two elements, which are called respectively on account of their shape, the rods and cones. You will notice a little dip in the centre of the retina—this is the fovea, and it is the region of most distinct vision. In the fovea only cones are present. External to the fovea the rods are arranged in rings round the cones, and the number of rods to cones increases as portions of the retina further from the fovea are taken, except at the extreme periphery, where, again, only cones are found. In the outer segment of each rod there is a rose-coloured substance, the visual purple, which is photochemically sensitive to light. This visual purple is not found in the cones, but only in the rods. It was for this reason that it was not considered to be essential to vision, because it was absent from the cones, and only cones are to be found in the fovea, the region of most distinct vision. The rods and cones project into a thin layer of fluid, which is kept in its place by a membrane. It occurred to me that the visual purple was diffused into this liquid and on being decomposed by light stimulated the cones, thereby setting up a nerve impulse, which caused the sensation of vision. This theory gave an immediate explanation to a large number of facts.

The decomposition of the visual purple by light stimulates the ends of the cones, and a visual impulse is set up which is conveyed through the optic nerve fibres to the brain. The character of the impulse differs according to the wave-length of the light causing it. Therefore in the impulse itself we have the physiological basis of the sensation of light, and in the quality of the impulse the physiological basis of the sensation of colour. The impulse being conveyed along the optic nerve to the brain, stimulates the visual centre causing a sensation of light, and then passing on to the colour perceiving centre, causes a sensation of colour. But though the impulses vary in character according to the wave-length of the light causing them, the colour perceiving centre is not able to discriminate between the character of adjacent impulses, the nerve cells not being sufficiently developed for the purpose.

Even with the normal-sighted there is room for much further development in the discrimination of colour, but when the development is not up to the normal standard or there is a defect in any portion of the apparatus diminishing the power of discrimination, colour-blindness is the result.

We now come to the test which should be used for sailors and engine drivers.

On account of the arrangement of signals by sea and land it is necessary that persons employed in the marine and railway services should be able to recognise and distinguish between the standard red, green, and white lights, under all conditions in which they are likely to be placed.

It is not only necessary to find out whether a person is able to distinguish between the red, green, and white lights, but to ascertain as well that he thoroughly understands what is meant by colour, and the individual character of red, green, and white respectively. Too little attention has been paid to this in constructing tests for colour-blindness, and those who have had much practical experience in testing for this defect, are aware of the ignorance which exists among uneducated persons with regard to colours. Many are under the impression that every shade of a colour is a fresh colour, and others have the most novel ideas with respect to colours.

It is necessary that a sailor or engine-driver should be able to recognise a red, green, or white light by its character of redness, greenness, or whiteness respectively; that is to say that the examinee has definite ideas of colour and is able to reason with respect to them. All persons who are not able, through physical defect, to have definite ideas of the standard colours and to be able to distinguish between them, must be excluded from the marine and railway services. An engine-driver or sailor has to name a coloured light when he sees it, not to match it. He has to say to himself, "This is a red light, therefore there is danger," and this is practically the same as if he made the observation out loud. Therefore from the very commencement we have colour names introduced and it is impossible to exclude them. Making a person name a colour is an advantage, because the colour name excludes the element of shade. If, as some persons have said in the past, testing by colour-names is useless then the whole series of colour-names is useless. But if I say to a friend, "That tile is red," and he agrees with me, it is evident that one object the colour of which is by him classed as red, is also classed as red by me. The ordinary colour-names, red, blue, yellow, and green, form excellent bases for classification. The engine-driver is told that red is a "danger" signal, green a "caution" signal and white an "all right" signal. Therefore it is necessary that he should know what is meant by these colours. It must be noticed that it is on account of there being so many variations in hue that such great difficulty has been found in constructing an adequate test for colour-blindness, as it is the definite colours and not the variations of them of which we wish to know the number. It will be seen that it is not merely a matter of shade as far as the colour-blind are concerned, but a distinct difference in tint. The normal sighted could divide the green of the spectrum into yellow-green, green, and blue-green, and would in the majority of cases, be able to range all greens under these three classes. The dichromic colour-blind see two colours only, and name colours in this way.

The test which should be used for the marine and railway services, is a lantern in which the requisite conditions are represented. The lantern* which you see here is the official test of the Navy, and the original was constructed by me for the Board of Trade over thirty years ago. It is obvious that a man who cannot distinguish the red, green, and white lights in this lantern will not be able to do so in actual practice, and this fact is easily proved by testing with actual signal lights.

Here is a new test for colour-blindness, a Card Test,‡ though I wish to state expressly that this is not intended for the decisive testing of sailors or railway men, but may be used as a supplementary test. It is for use when my lantern is not available and is probably the simplest for demonstrating to the normal-sighted person defective colour vision in a subject. The principle involved is the perception of difference between two colours presented in a special diagram of spots of irregular shape and various tones. On a ground of separate spots of one colour a letter is formed in spots of another colour. The test consists in discriminating between the colours, and hence recognising the letters.

This test is useful for children as it is of importance that anyone who is colour-blind should know of it at the earliest time, so that he can avoid occupations in which an accurate colour-sense is necessary.

In conclusion many of you would probaby like to know why the wool test is such a failure. When I pointed out over thirty years ago how defective and unfair this test was, there was much opposition as it was generally considered to be perfect, as it was based on the most popular theory of colour-vision of the time and a special Committee of the Royal Society decided in its favour. It is now obsolete as it allows over 50 per cent. of dangerously colour-blind persons to pass, and it will be noticed in certain reports that of those who were rejected by the wool test and who appealed, over 50 per cent. were found to be normal-sighted and had been rejected wrongly.

This fact cannot be explained on the older theories. The older theories were reduction theories, that is to say, something was absolutely lost in the same sense as a man being born without one arm. He obviously could not do work which required two arms. My theory assumes that there is no actual loss when there is no defect of light perception, but that the power of discrimination is less owing to imperfect development. To complete the analogy we can compare a colour-blind man with a man

*Sole Makers, Reiner & Keeler, 9, Vere St., W.
‡Published by G. Bell & Son, London.

having two arms but with poorly developed muscles. He obviously could not lift a box which was quite easy to a stronger man. The analogy must, however, not be carried further. There is no record of a colour-blind man who has become normal through training.

The colour-blind people who can pass the wool test see a slight difference between the colours, but the smallness of this is shown by the Card Test.

DISCUSSION.

THE CHAIRMAN (Sir Philip Lloyd-Greame, K.B.E., M.C., M.P.) said he was sure he would be expressing the feelings of the whole meeting in saying how very much they appreciated the paper to which they had just listened. He was extremely glad to be present, and very much appreciated the compliment the Royal Society of Arts had paid to the Board of Trade, in inviting him to preside, because the whole question of colour vision and colour blindness was one in which the Board of Trade necessarily took the keenest possible interest. It was absolutely essential in the public interest that the Board of Trade should have tests for navigating officers which were completely effective and at the same time absolutely fair, and it had therefore been of particular interest to him to hear from the author so clear an explanation of the genesis of the tests which were now applied. He would like to take the present opportunity of recording the very real debt which the Board of Trade owed to the author. It was unnecessary for him, in an assembly of people far more intimately acquainted with, though not more appreciative of, the author's attainments than he was himself, to refer to them in any detail, but he might say that the author's achievements in the field of colour vision had won for him not a national but an international reputation in his particular field of work. The author's tests were accepted and now, he thought, exclusively applied in the Navy, and personally he had a vivid recollection of the value of those tests in the Ministry of National Service, in which he served during the last year of the war. Every department, whether of State or of science, that was interested in the subject had some claim upon the author, but the Board of Trade had a special claim on him, because it was at least thirty years ago that the author, during some years of service in the Board of Trade, laid the foundations of the work which he was afterwards to consummate. That work was not only of peculiar interest but also of peculiar value, because thirty years ago the importance of the subject was not in the least appreciated, as it was now, and consequently there was not the same incentive as there was at the present time to make the study of it that the author then began. The Board of Trade had recently persuaded the author to accept the post of Special Examiner in Sight Tests, and he was convinced that no better man could have been found in any country to occupy that position. The author was now in effect for the Board of Trade and for all those whom the Board had to license the supreme court of appeal, and he could say with confidence that to no court of appeal could people go with more certainty of receiving fair treatment and an accurate decision than to the author. It gave the Board confidence to know that he was there applying his tests; it gave the public confidence; and it gave those who submitted themselves to the tests the most complete confidence, and that was the best test of all. They all felt sure that no one passed who in the public interest ought not to pass, and at the same time that no one failed who was entitled to pass. He sincerely hoped that the author's association with the Board of Trade would be long continued.

THE SECRETARY read the following letter from Sir James Porter, K.C.B., K.C.M.G., M.D., LL.D., Director General of the Naval Medical Service, 1908-13:—

"I have to thank you for your kind invitation, and very greatly regret my inability to be present at Dr. Edridge-Green's paper on 'Colour Vision and Colour Blindness.'

"Many years ago when conclusive evidence was brought before me of the inadequacy of the Wool Tests then in use in the Navy, I turned to Dr. Edridge-Green, who came to the Admiralty, and, without fee or reward, fully explained his tests to our most experienced examiners, with the result that they were officially adopted by the Service. Though at first frequently assailed they *invariably* proved correct on appeal and re-examination. Then the opponents of the system—some of them High Priests of Science—were plentiful and very active, but to-day they are silent. Truth has prevailed. The splendidly unselfish fight of a life-time has at last established the Right.

"Dr. Edridge-Green has deserved well of his country. He has given us the means of averting appalling disasters by eliminating the colour blind from control of vessels and fleets at sea."

MR. W. J. THOROWGOOD, speaking from a signalling point of view, said that everyone must appreciate the work the author had done, and anyone who had to deal with men that had to distinguish between different colours knew the difficulties that were met with in that connection. It was a very serious thing for a man in the railway service to arrive at middle age and then find that his sight had begun to fail and that he had to give up his work as a driver or signalman, as the case might be.

He had been trying some experiments lately, and was rather struck by the pictures that the author had put upon the screen. In all those pictures he thought that, although the colours were different, the forms of the various animals, trees, and so forth, were almost true, and were very good copies of the original drawing. Was it necessary to use different colours in signalling, say, on a railway at night? In the day time the signals were given to the driver not by colour but by position, and could not the red and green colours used at night be dispensed with and only white be used, and the signals given by position, as in the day time? He had tried using four white lights in that way at Waterloo Station and one or two other places, and had obtained excellent results, and in America on the Philadelphia Railway there were miles and miles of railway signalled with four white lights—position lights. All that was necessary was to have four white lights in a horizontal line to indicate "danger"; four white lights diagonally to indicate "caution, and four white lights vertically to indicate "clear." That system might be difficult to adopt at sea, owing to the constant motion, but it would be quite practicable on a railway, where the signal posts were fixed in one position. It had been suggested recently that three colours should be used for signals instead of two, and that an amber light should be introduced as well as having the green and red. He had shown the amber light to men of intelligence and they said it was red, but immediately he showed them a red light they said they had made a mistake and that the first light was not red at all but a different colour altogether. Glass in a lamp might appear to be two or three different colours. For instance, he had had cases where he had a good green or a good red colour used with an oil lamp, a gas lamp, or an electric light, and the colour appeared to be quite different with these different illuminants. It was extremely difficult to obtain glass the same colour every time; even in the same sheet of glass there were different shades of colour; and it would be very useful if the manufacturers could devise some means for producing glass of a uniform colour.

Professor E. Neville da Costa Andrade said it might be of some interest to contrast the author's theory with two which still prevailed in some quarters, *i.e.*, the three-colour theory and what was known as the duplicity theory. The three-colour theory in general arose from the consideration that any colour could be represented by taking three given colours which were always the same and combining them in different proportions, just as in colour printing there were three given colours combined in different proportions to obtain any shade required. Hence it was imagined that in the retina of the eye there were three sets of nerve fibres—one that detected red, one that detected green, and one that detected violet—and that they together combined in different proportions to give a sensation of the hue. Dr. Edridge-Green had put that theory out of court by showing, for instance, that the red sensation might be lacking entirely at one end of the spectrum without affecting the rest of the spectrum. According to the three-colour theory, if the red sensation were lacking at one end of the spectrum it must be lacking everywhere, and that would affect the whole of the colours of the spectrum. Also, on that theory the yellow sensation must be composed of a certain amount of violet, red and green. The author had given many reasons to show that the yellow sensation was simple and not made up of three sensations. Another point against the three-colour theory was that no one had ever found three elements in the eye that were different in any way—one that detected green, one red and one violet. In the duplicity theory the rods of the retina were supposed to perceive faint lights and the cones were supposed to perceive bright lights. The cones alone were supposed to see differences of colour. If a bright spectrum was made fainter a normal-sighted man would see only grey. According to the duplicity theory it was the rods that were then used. Against that there was the fact that if one sat in the dark long enough the spectrum would come back coloured. According to the author's theory, when the light fell on the rods they liberated the visual purple and that rendered the cones sensitive to the light. Did not that explain, amongst other things, a fact that might have struck some people, *i.e.*, that at the cinema, for instance, it was found as time went on that if the room were perfectly dark one could no longer see the screen as well as if the room were partially light? The light coming from within a fairly wide angle fell on the part of the retina where there were rods, and the visual purple being liberated everything could be seen quite well. He thought it was rather dangerous to make too close an analogy between music and vision, because the ear was an analysing instrument and the eye was not. If one heard a chord struck on the piano, for instance, one could tell of what notes it was composed, but if a light fell on the eye it was impossible for anyone to say how that light was made up.

Miss M. Baddely said she would like to ask the author if people who were colour blind were also insensitive to musical notes.

Mr. W. G. Raffé wished to make one or two observations on the author's theory by way of questions, particularly in view of the remarks of Professor Andrade on the inability of people to make a correct analogy between

ight and sound. The trouble seemed to be caused by the fact that people were inclined to keep their scientific theories in watertight compartments. In dealing with molecular and atomic theories, they seemed to regard them as applying to materials outside their own bodies and were apt to forget that those also were made up of physical materials and were possessed of molecular properties. He suggested that light and colour observations were essentially things that took place in ultra-molecular circumstances and not in physical circumstances, as sound did. Sound, therefore, must be a comparatively simple thing, and that was the reason why it was possible to associate one series of chords or to select one series of sounds by the ear. A French scientist recently caused astonishment by referring to cases in which sight could be exercised through other parts of the body than the eye. Presumably according to that French scientist other parts of the body could be similarly used if certain phases of consciousness were damped down and the emotional or intellectual parts of the brain were directed to some other part of the body than the eye under the influence of hypnosis. If it was true that vision took place in ultramolecular circumstances, it seemed to him that the eye is that part of the body which contains the largest number of points of what he might call extreme sensitivenesss, to which the word "resonance" seemed to be particularly applicable. If it was correct that sound was associated with what he might call grosser physical conditions, then it might be assumed that the ear could not reach to such a high degree of sensibility as the eye, and consequently could only "listen to" or associate itself with one series of chords at any given time. A number of colours could be seen at once—although really not at more than one particular point, the centre of vision, could they be distinguished—but only one set of sounds could be listened to at once. He thought the author's magnificent public work might be further extended by the introduction of colour tests into schools for the use of children, particularly those who were going into trades where colour was a matter of importance. Such tests might be added to the work of the ordinary medical officer and might be made a good deal of use of in connection with technical and art school work.

Professor A. O. Rankine said that, with regard to the pictures and the copies of them that the author had shown on the screen, he would like to ask whether the people who had tried to copy the pictures mixed the colours for themselves, or were a number of colours already mixed placed before them, so that all they had to do was to select the tints they required. The reason he asked the question was because it was very difficult to understand why even a person whose colour vision was defective should represent as brown something which was in the original red, if red of exactly the right tint was placed before him. He thought it would be a good deal more convincing if the man did not have to select from colours which were to hand but had to mix them *ab initio*, as it were.

Mr. J. MacNab (Principal, Heatherley School of Art) said with regard to the pictures shown on the screen it struck him that in some cases the colour-blind man who was trying to copy the pictures was rather badly out not only with the colours but with the values of the colours. Personally he was not a physicist or a physiologist but an artist, and as a painter colour was important to him. When artists talked about values they meant the lightness of one colour as compared with the darkness of another, and in certain cases he noticed that in the pictures shown by the author a rather dark red in the original drawing had been reproduced as a very light green. Was it necessary that a colour-blind man should be so badly out in the values of the colours? Had that anything to do with the fact of his being colour-blind, or was it merely a rather bad shot?

Mr. J. H. Napier said he wondered why it was that when a man was copying one of the coloured pictures shown by the author and saw what appeared green in the original drawing he did not use a pigment which corresponded to that when making his copy. One would think that if the man had a palette with red and green on it he would naturally take that green pigment to correspond to the green in the original. Was it that he saw green on a printed diagram differently from the way in which he saw green on the palette?

Dr. Edridge-Green, in reply, desired to thank Sir Philip Lloyd-Greame for the extremely kind terms in which he had referred to his work. The question of using white lights in signalling at night and indicating the different signals by the position of the white lights had been very carefully gone into. As a matter of fact, it was much more suitable for use at sea than on land, because a motor car going behind a light, for instance, might easily lead to a railway accident owing to its altering the nature of the light seen at a distance. As long as it was possible to use colours it certainly seemed advisable to do so. With reference to Mr. Raffé's remarks, he suggested that Mr. Raffé should refer to the papers of Dr. Houston, a very able physicist, who was Lecturer on Physical Optics at Glasgow University. His own theory of vision had been re-discovered by Dr. Houston, who had arrived at exactly the same theory on mathe-

matical and physical grounds, thus closing up the only avenue of attack that could be used against the theory.[*] With regard to the question as to whether those who were colour-blind were also musically defective, it was generally the other way about. There was a greater percentage of colour-blind people amongst musicians. With reference to the value of the colours used in the reproductions he had shown, the pictures were made for lantern slides, and it was not intended that they should be taken as absolutely correct on points that they were not intended to illustrate. The pictures were intended to show the colours, and if a heavy green or a heavy red had been used it would have appeared as almost black. The extraordinary accuracy in regard to shades displayed by many of the colour-blind was remarkable. He had known a Royal Academician who had to ask his wife to select his colours for him. In the case of the pictures he had shown on the screen, a number of colours were given on the palettes to the man who was to copy them; he looked at the painting and said to himself "This colour is red" or "This colour is green," as the case might be, and he then looked on the palette and found a red or green, or the colour that appeared to him most like the colour in the original. In certain cases if ten thousand different tints were given to him and he was allowed to spend hours on very careful matching he might eventually arrive at a complete match, just as he would with the wool test. In the ordinary way he was not given reds and greens of the exact shade and hue of those in the original. A normal-sighted person represented red by red; he might not be able to get the exact shade or hue in the way an artist would, but he would not pick out a green for a red.

On the motion of the Chairman, a hearty vote of thanks was accorded to the author for his interesting paper, and the meeting terminated.

Mr. W. C. Acfield, Signal Superintendent, Midland Railway, writes:—

I was exceedingly sorry I was unable to be present at the reading and discussion of Dr. F. W. Edridge-Green's paper on the question of "Colour Vision and Colour Blindness," it being a subject of special interest and importance on account of the various coloured lights in use on railways.

The author makes mention of red, green and white lights being used for "signalling" purposes, but, as a matter of fact, white lights are used in signals mainly for defining only the actual position of a signal, rather than as an indication of "danger" or "clear."

In present-day systems of signalling, particularly on some electrified lines of railway, signals are provided with three different coloured glasses where the so-called three-position signa is used, viz., red for "danger," yellow for "caution," and green for "all right," the yellow light being of a more or less orange shade of colour.

Such being the case, although perhaps putting forward a question already raised in the discussion on the paper, I should be particularly interested to hear Dr. Edridge-Green's opinion as to what possible colour a yellow light might appear to a man aspiring to become an engine-driver, and at the same time coming under the head of dichromic or trichromic, white lights being looked upon by way of argument as a colour.

[*] See "The Physiology of Vision." G. Bell & Sons, 1920.

OBITUARY.

Sir William de Wiveleslie Abney, K.C.B., D.Sc., D.C.L., F.R.S.—By the death of Sir William Abney, at Folkestone, on the 3rd inst., the Society loses one who in past years had rendered it valuable services in more than one capacity. Born in 1844, the son of Canon Abney, of Measham Hall, Leicestershire, he was educated at Rossall, and became a Lieutenant in the Royal Engineers in 1861 (Captain in 1873). It was, no doubt, his early devotion to science that led to his connexion with the Science and Art Department, after he had served as instructor in chemistry at Chatham, and to his consequent retirement from the Army in 1881.

In 1884 he was appointed Assistant Director for Science in the Department, becoming Director in 1893 and Assistant Secretary in 1899. When the two Educational Departments were amalgamated in the Board of Education, he was made Assistant Secretary to the Board, and in 1903, on his retirement from active official work, he became Scientific Adviser to the Board.

It was, however, as a student of scientific photography that he made his great reputation, for he was, for many years, the recognised authority on that subject in England, and there were very few in other countries to compare with him; certainly none to surpass. He took up photography at a very early age, in the days of wet plates and waxed paper negatives before the invention of gelatine dry plates or of any dry plates at all. He was almost certainly the first to suggest, and to employ, photography in military surveying, since he used the camera to provide himself with substitutes for the topographical sketches he had to make in the course of his training as an engineer. In 1871 he read his first paper to the Photographic Society, and in 1874 he took part in one of the expeditions for observing the transit of Venus. In 1876 he was elected F.R.S.

No account of his numerous photographic researches will be expected here; it must

suffice to say that he must be allotted the chief credit for having worked out and enunciated the main principles on which the theory and practice of photography are based. He had a few—very few—predecessors in this country and in France. He had some contemporaries who contributed their share. He has had a crowd of successors who have elaborated his work until photography has become, on one side the most valuable handmaid of science, and on the other, the basis of several important industries and a valuable adjunct to many others.

The results of his labours will be found embodied in his two best-known works: "Instruction in Photography," and "A Treatise on Photography." Each of these had reached its tenth edition by the end of the last century. The former was the universal and indispensable text book of every photographer. It grew and grew as the art of photography developed itself with the invention of new processes, the introduction of new materials, the construction of new appliances, and it still remains a storehouse of information on all matters which are not absolutely later than the date of its last edition. The second book, the Treatise, is a more general account of the science, still valuable, though it, too, has been out-stripped by the rapid development of the subject with which it deals.

In the later part of his life, Sir William Abney devoted his attention mainly to the subject of colour. Most of his results were embodied in his "Colour Measurement and Mixture," 1891 (an enlarged reprint of one of his Cantor lecture courses). The main outcome of this work was the construction of his ingenious "Colour-patch" apparatus, by means of which rays from any part of the spectrum could be selected and combined in any desired proportions to form a patch of colour corresponding with the particular colour it was desired to reproduce.

The basis was thus provided for a complete analysis and classification of all tints, however various. Much valuable information was obtained by the use of this apparatus, and many interesting questions have been answered, but the difficulties of applying it usefully to scientific and industrial classification—difficulties of texture and the like—still remain, and the inventor's hopes of practical results have hardly yet been realised.

Of his association with the Society it may be enough to say that while the scientific results of his researches of necessity were published before the Royal, Physical or Photographic Societies, Sir William Abney never failed to bring the practical results before the Society of Arts. He gave four courses of Cantor Lectures, and one Special Lecture; and six papers, the first in 1880 and the last in 1914.

Though he was so long associated with the Society's work, it was not until 1894 that he became a member. The same year he was elected to the Council. He remained on the Council in various capacities almost continuously until 1915, serving as its Chairman for two years, 1903-4-5.

H. T. W.

FINNISH TAR INDUSTRY.

Although the production of tar still plays its part in Finnish industrial life, it has now become quite insignificant compared with its importance 50 years ago. The following table shows the approximate annual quantity and value of the tar output for periods since 1863, when the industry was at its height, after having been stopped almost entirely during the Crimean War:—

Period.	Quantity	Value
	Hectolitres.	Finnish Marks
About 1863 ...	300,000	——
1875	200,000	3,000,000
1886-1895	148,000	1,810,000
1896-1905	89,000	1,420,000
1906-1915	17,000	401,000

Hectolitre = 22 Imperial Gallons;

Period.	Quantity.	Value
	Hectolitres.	Finnish Marks.
1916	18,755	1,875,000
1917	1,571	251,000
1918	47,814	6,595,333
1919 (11 months) ...	5,297	1,012,680

The par value of the Finnish Mark is 9.6d.

In 1918 the stocks of tar held over during the war were exported, causing a considerable rise in the price, but during the year 1919 the price dropped to 200 marks per hectolitre from its previous level of 400 marks.

According to a report by the U.S. Consular Assistant at Helsingfors, the following primitive method of getting tar which, fortunately, is being done away with, was used extensively. The bark is stripped off each pine tree to a height of seven or eight feet, a narrow strip being left on the north side, where the bark is strongest, in order to preserve the life of the tree. This stripping goes on for three or four years, or as long as the tree will stand it, each time a little higher, and a thick yellow resin oozes out of the peeled wood and forms a thick crust on the trunk. When the last treatment takes place the narrow strip of bark that has been left on to preserve the tree is also removed, and when the snow is on the ground those trees which have had their final treatment are felled and carried on sledges to the tar kilns, which are huge, saucer-shaped affairs constructed of wooden logs bricked over and cemented, and are usually built along the river banks.

The tree trunks are cut into pieces of about

a yard in length and piled upon the kiln, then covered with turf and kindled at several points. The kiln smoulders for a couple of weeks, the resin crusts of the trunks gradually melting and the tar flowing down the kiln to the hole in the centre, with which pipes are connected that conduct the tar into barrels. Most of the kilns are large enough to yield more than 100 barrels, or 40,000 pounds, of tar at one burning. If the kilns are not situated near any waterway, the tar is transported to the rivers by fixing the barrels to the axles held together by beams of wood, so that the barrels themselves act as wheels, and in this way the horses can pull them over the rough roads very easily.

As soon as the ice melts in the rivers the tar boats appear and carry the barrels downstream to the coast. Most of this transportation by tar boats is done on the Ulea River, which is full of rapids, and down which the boats shoot at a tremendous rate of speed, piloted by expert steersmen. The boats are about 40 feet long and only three feet broad, very lightly built, so as to yield before a slight shock, but with lofty sides to keep out the foaming water. There is seldom a single nail or a piece of iron of any kind in their structure, the thin planks being bound together with the stoutest wood fibre, after which the boat is liberally coated with tar.

A boat will carry about 30 barrels, or six tons, of tar on each trip, but it is built so light that it can be pulled up the rapids again on the return journey. The crew generally consists of a steersman at the stern, two women amidships to row in the calm water between the rapids, and two boatmen in the bows. Many tar boats make as many as three journeys down the Ulea River to the coast during the short summer, and they never return empty, but bring back with them a small load of provisions for winter use. Most of the peasants who are employed during the summer in burning and transporting tar spend the hard winter in felling trees and carrying them over the snow to the tar kilns or in making strong barrels for the tar.

Tar burning has been an important business in Ostrobothnia since the sixteenth century, but it has resulted in a wasteful destruction of fine pine forests. Enormous tracts of pine wood, especially in Uleaborg and the interior of Vasa, have been either destroyed or replaced by firs because the pines were cut down when 40 to 80 years old and used in making tar. Since 1863, the boom year of this industry, ships of iron and steel have largely taken the place of wood vessels and tar has since been in less demand, fortunately for Finland's valuable forests. The tar burners are now beginning to make use of other material, such as stumps, roots, waste from sawmills, and young trees cut down where the forest growth is thinned—raw material for which there is no other use. It has been estimated that a large tar kiln will produce about £100 worth of tar at one burning; but considering the value of raw material and the amount of work required in transporting the tar to its destination, there is not much left for profit and wages. Nevertheless, more than 12,000 barrels of tar were exported from Uleaborg in 1908, and even during the summer of 1919 approximately the same amount was transported to this city, either down the Ulea River or by railway from various parts of Ostrobothnia.

The constantly increasing demand for wood pulp has raised the prices of the smaller fir trees, which are also used in tar burning, to a point where tar distilling was no longer profitable, and this has caused the industry to undergo very important changes during recent years. Most of the tar is produced nowadays in modern factories, transportation by waterways has given way almost entirely to railway transportation, and the centre of the tar industry is no longer at Uleaborg, but along the railways between Tampere (Tammerfors), Jyvaskyla, and Seinajoki, whence the product is carried to the harbours along the southern coast. The northern districts, no doubt, will come into their own again as soon as railway communication has developed in this direction.

The location of these factories is dependent not only upon the railways, but also upon the abundance of raw material and the method of treatment. The method used by the modern tar factories consists in cutting into pieces and burning in furnaces the stumps of pine and fir trees, which have first been dried for several months in the air, after having been taken out of the ground. The stumps must be at least seven years old, and sometimes have been standing as long as 25 years, but opinions differ concerning the age at which the resin is well concentrated in the centre of the mouldering stump. Most of the factories are found in the central wood districts, where the stumps are very abundant and railway transportation is available, but the Nurmi Kajana-Uleaborg line, which is under construction, will play an important part in the re-establishment of the tar industry in the northern districts.

Besides the tar itself, this industry results in minor products, such as crude resin, turpentine, pitch, lampblack and charcoal. There has been some exportation of crude resin, which is scraped from the barks of the trees standing in the woods, but in 1918-19 a special organization for collecting the resin throughout the country found wages so high that exportation of the product caused a loss. The resin is now used in the factories in Finland, where rosin is produced for varnishes and for the paper industry, which also imports large quantities of this material from the United States.

GENERAL NOTES.

Alchol Production on Sugar Plantations.—Increased attention is being given to the question of production, on sugar plantations, of alcohol for power and lighting purposes. On the Santa Ana Estate in Tucuman, alcohol made on the spot and denatured under fiscal supervision costs no more than 8d. per gallon. In Hawaii it is announced in the *International Sugar Journal* that a denatured alcohol plant is to be erected on one sugar plantation, which will at the start produce 300 gallons daily at a cost of not more than 10d. per gallon and make the plantation independent of imported gasoline. Nearer home, the cost of producing 95 per cent. alcohol when derived from fermentable sugars is put by one authority at no more than 9d. per gallon, including cost of depreciation of plant. These prices show a considerable advantage as compared with those ruling for gasoline or petrol, and to say the least they should stimulate effort towards a wider and larger production of this source of power, even if it be the case that local consumption only is supplied. In view of the uncertainty of the world's oil supplies, the less demand there is for the light petroleum distillates on the part of those industrial centres that can profitably produce denatured alcohol, the better it will be for the others who depend chiefly on the oil products.

New Process for Converting Ore into Metal.—A Norwegian firm, A/S Norsk Staal (Elektrisk-Gas-Reduktion), has worked out, during the war, a general process for reducing tungstic acid into tungsten powder and molybdenum sulphide into metallic molybdenum. It claims, according to *Commerce Reports*, that the final products, which are in the form of small tablets, are of the most superior quality, being completely free from sulphur, carbon, or oxygen. It also says that the price for converting the ores into metal is lower than by any other method known by it. It is at present projecting a plant for the reduction of tungstic acid in Norway. The firm is located at Dronningensgt, 22, Christiania, Norway.

Shale as Fuel in Esthonia.—It is stated in the *Esthonian Review*, a weekly published by the Foreign Office of the provisional Esthonian Governme that shale is being employed in Esthonia now for all manner of purposes; for instance, the Reval gas factory is using it exclusively for producing gas. It cannot yet be burnt as fuel in the fire boxes, at any rate, as they are constructed at present, because of the large quantity of ash, and the factory, therefore, is using wood as fuel. The quantity of gas obtainable from the shale is greater than from coal. The Reval factory has obtained up to the present 120,000 poods (4,333,500 pounds) of shale. The Port-Kunda cement factory has recently purchased 60,000 poods (2,166,750 pounds) from the Ministry of Trade and Commerce and has a similar amount ordered. It is intended to employ shale mixed with 50 per cent. of coal dust on the manufacture of cement. Experiments in firing locomotives with shale have given very satisfactory results, and the railway factory in Reval is now reconstructing the fire box on one of the engines with the intention of employing shale as fuel. During a recent excursion to the island of Naissaar (Nargo), undertaken by a special commission in order to acquaint themselves with the local conditions, shale was employed exclusively as fuel in place of coal. The experiment turned out quite satisfactorily, a head of steam being obtained equal to that when coal is employed. The difference in cost is remarkable, the price of coal at present being no less than 30 marks a pood and that of shale only 3 marks, so that even if the consumption be more than double, a great saving would be effected. The engineers are of opinion that when fire boxes are made suitable for the employment of shale, it will be much cheaper to use this fuel than coal. It is to be hoped that these experiments will attract interest to shale and that the question will be taken up of employing it as fuel in our industrial undertakings.

Musical Instrument Market of Australia and New Zealand.—The imports of pianos into Australia, says the American Consul General in Melbourne, which formerly approximated 20,000 annually, fell to 8,000 last year, this being partly due to the shortage of cargo space, and partly to the growth in popularity of the instruments made in Australia about 4,000 of which are now manufactured annually. These are constructed as far as possible of Australian materials, although the small items, such as ivories, wire, and actions are not yet made there. The total value of other musical instruments, including a number of American player pianos, imported in 1919, was approximately $475,000. While the greater number of instruments come from Great Britain, America is not far behind, especially in supplying band instruments and talking machines. Better grades of all kinds of instruments are more popular than those of cheaper make. On the other hand, practically all of New Zealand's imports of musical instruments, which before the war came largely from Germany, now come from the United States and Canada. In 1918 (the latest year for which statistics are available) the total imports approximated in value $355,500. Sheet music comes very largely from the United States, and may be seen in the shop windows of nearly all music stores. It would seem that there might be a further opening for higher-class music.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock (unless otherwise announced):—

DECEMBER 15.—MAJOR-GENERAL THE RIGHT HON. LORD LOVAT, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., "Forestry." THE RIGHT HON. THE EARL OF SELBORNE, K.G., G.C.M.G., President of the Board of Agriculture 1915-1916, in the Chair.

FRIDAY, DECEMBER 17. — COLONEL ROBERT STORDY, C.B.E., D.S.O., "The Breeding of Sheep, Llamas and Alpacas in Peru, with a view to supplying improved Raw Material for the Wool and other Textile Trades."

Papers to be read after Christmas:—

SIR MARCUS SAMUEL, Bt., "The General Position of the Oil Question."

SIR DANIEL HALL, K.C.B., F.R.S., "The present position of Agricultural Research." (Trueman Wood Lecture).

LAWSON, F. M., Assoc.M.Inst.C.E., "The Future of Works Management." SIR ROBERT A. HADFIELD, Bt., D.Sc., D.Met., F.R.S., in the Chair.

A. F. BAILIE, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World." PROFESSOR SIR JOHN CADMAN, K.C.M.G., D.Sc., in the Chair.

A. ABBOTT (Department of Scientific and Industrial Research), "The Origin and Development of the Research Associations Established by the Department."

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

WILLIAM CRAMP, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice."

CHARLES S. MYERS, M.D., Sc.D., F.R.S., Director of the Psychological Laboratory, and Lecturer in Experimental Psychology, University of Cambridge, "Industrial Fatigue." (Aldred Lecture.) W. L. HICHENS (Chairman, Messrs. Cammell, Laird and Co., Ltd.) in the Chair.

CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

WILLIAM ROTHENSTEIN, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England."

WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper Pulp Supplies from India."

SIR CHARLES H. BEDFORD, LL.D., D.Sc., "Industrial (including Power) Alcohol."

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

G. C. CREELMAN, LL.D., B.S.A., Agent-General for Ontario, "Modern Agriculture."

PROF. R. S. TROUP, M.A., C.I.E., Indian Forest Service; Professor of Forestry, University of Oxford, "Indian Timber."

FRED C. CORNELL, O.B.E., "The Alluvial Diamondiferous Deposits of South and South-West Africa." MAJOR SIR HUMPHREY LEGGETT, R.E., D.S.O., in the Chair.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock:—

January 21, February 18, March 4, April 22, May 27.

COLONIAL SECTION.

Tuesday afternoons, at 4.30 o'clock:—

February 1, April 5, May 3.

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

A. CHASTON CHAPMAN, F.R.S., F.I.C., "Micro-Organisms and some of their Industrial Uses." Three Lectures.

Syllabus.

LECTURE II.—DECEMBER 13.—Use of bacteria in the Amylo-Process for the purpose of reducing the waste of Nitrogen—Biochemical production of Citric Acid, Butyric Acid and Fumaric Acid—Manufacture of Lactic Acid and Butyric Acid by fermentation processes—Manufacture of Vinegar.

LECTURE III.—DECEMBER 20.—Bacterial production of Acetone and Butyl Alcohol—Brief references to the importance of Micro-Organisms in Agriculture, Dairying and Sewage Treatment—The utilisation of waste Distillery Liquors—Use of Yeast in the production of nitrogenous food stuffs, so called "Mineral" Yeast—Need for the extended study of Industrial Microbiology in this country, and desirability of establishing a National Institute devoted to that subject.

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures. February 14, 21 and 28.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.C., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

HOWARD LECTURES.

ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E., "Aero Engines." Three Lectures. January 17, 24, 31.

JUVENILE LECTURE.

Thursday afternoon, January 6, 1921, at 3 o'clock:—

SIR FREDERICK BRIDGE, C.V.O., M.A., Mus. Doc., Emeritus Organist, Westminster Abbey, "The Cries of London which Children heard in Shakespeare's Time" (with musical illustrations).

MEETINGS FOR THE ENSUING WEEK.*

MONDAY, DECEMBER 13 .. Post Office Electrical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m.

Mechanical Engineers, Institution of, Storey's Gate, S.W., 7 p.m. (Graduates' Section). Mr. A. G. Hopkins, "Die Casting."

Transport Institute of, at the Institute of Civil Engineers, Great George Street, S.W. Lord Montagu of Beaulieu, "The Development of Road Transport."

Brewing, Institute of (London Section), Imperial Hotel, Russell Square, W.C., 8 p.m. 1. Annual General Meeting. 2. Mr. H. L. Hind, "The Reconstruction of French Breweries."

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m. Mr. F. H. A. Hardcastle, "The Work of the Measuring and Quantity Surveyor, and the use and abuse of Bills of Quantities."

Geographical Society, Kensington Gardens, W., 5 p.m. Lt.-Commander R. T. Gould, "The History of the Chronometer."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. M. S. Briggs, "Saracenic Architecture in Egypt and Palestine."

Faraday Society, at the Chemical Society, Burlington House, W., 8.15 p.m. 1. Professor E. D. Campbell, "A Force Field Dissociation Theory of Solution Applied to some Properties of Steel." 2. Mr. A. L. Norbury, "The Electrical Resistivity of Dilute Metallic Solutions." 3. Mr. W. E. Hughes, "The Forms of Electro-deposited Iron and the Effect of Acid upon its Structure. Part I. Deposited from the Chloride Bath."

TUESDAY, DECEMBER 14 .. Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 5.30 p.m. Captain P. W. Mangin, "Drilling for Oil in Egypt and Mesopotamia."

Illuminating Engineering Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 8 p.m. The Secretary, "Report on Developments in Lamp and Lighting Appliances, etc."

Electrical Engineers, Institution of (Scottish Section), 207, Bath Street, Glasgow, 7 p.m. Mr. W. B. Woodhouse, "The Distribution of Electricity." (Midland Section), Hotel Metropole, Leeds, 7 p.m. Discussion on "Report on the Heating of Buried Cables."

Automobile Engineers, Institution of, 7, The Quadrant, Coventry, 7.45 p.m. Mr. A. Hayward, "Combustion."

Statistical Society, 9, Adelphi Terrace, W.C., 5.15 p.m.

Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Dr. R. A. Nicholson, "Some Arabic Poets of the Abbasin Period."

Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m. Sir Robert Abbott Hadfield and Mr. S. A. Main, "Notes on the Standardization of Shock Tests;" and discussion on this Paper and on the three Papers on "Notched-Bar" Tests previously read.

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. J. E. Reid, "Home Decoration."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Meeting of Scientific and Technical Section.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Capt. L. W. G. Malcolm, "The Ethnography of the Central Cameroons."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Sir Francis Younghusband, "India and England: the True Tie between them."

Metals, Institute of (Birmingham Section), Imperial Hotel, Temple Street, Birmingham, 7.30 p.m. Mr. W. R. Barclay, "Some War Experience in the Electro Deposition of Metals." (Scottish Section), 39, Elmbank Crescent, Glasgow, 8 p.m. Discussion on "Furnaces."

WEDNESDAY, DECEMBER 15 .. Glass Technology, Society of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 2.30 p.m.

Aeronautical Engineers, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. H. Sleeman, "The Possibilities of Aviation in the Dominions."

Meteorological Society, 70, Victoria Street, S.W., 8 p.m.

Geological Society, Burlington House, W., 5.30 p.m.

Electrical Engineers, Institution of (Wireless Section), at the Institution of Civil Engineers, Great George Street, S.W., 5.30 p.m. Capt. R. C. Trench, "Range of Wireless Stations." (S. Midland Section), Edmund Street, Birmingham, 7. p.m.

Automobile Engineers, Institution of, Chamber of Commerce, New Street, Birmingham, 7.30 p.m. Mr. J. Heard, "Transmission System for Light Cars."

THURSDAY, DECEMBER 16 .. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. H. Ricardo, "Possible Developments in Aircraft Engines."

Royal Society, Burlington House, W., 4.30 p.m.

Central Asian Society, 74, Grosvenor Street, W., 4.30 p.m. Major-General L. C. Dunsterville, "The Military Mission to North West Persia, 1918."

Automobile Engineers, Institution of, 28, Victoria Street, S.W., 8 p.m. Mr. T. E. B. Whiting, "Carburation."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Discussion on "Research on the Heating of Buried Cables."

Numismatic Society, 22, Russell Square, W.C., 6.30 p.m.

Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr. H. J. Deane, "Special Applications of Reinforced Concrete in Docks, with Special Reference to the Reinforced Concrete Gates at Tilbury Docks."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m.

FRIDAY, DECEMBER 17 .. Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m.

Metals, Institute of (Sheffield Section), The University, Sheffield, 7.30 p.m. Mr. J. K. Smith, "Some Alloys in the Foundry."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Dr. J. Walker, "Thermodynamic cycles in Relation to the Design and Future Development of Internal-Combustion Motors."

SATURDAY, DECEMBER 18 .. Chromatics, International College, of, Caxton Hall, Westminster, S.W., 3.15 p.m. Miss G. E. Cowell, "Symbolism of Colour—Ancient and Modern."

* For meetings of the Royal Society of Arts see page 39.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 20th, at 8 p.m. (Cantor Lecture.) A. CHASTON CHAPMAN, F.R.S., F.I.C., "Micro Organisms and some of their Industrial Uses." Lecture III.

COLONIAL SECTION.

On Monday, January 3rd, at 5 p.m., a paper (illustrated with original lantern views) on "The Alluvial Diamondiferous Deposits of South and South-West Africa" will be read by MR. FRED. C. CORNELL, O.B.E. The chair will be taken by MAJOR SIR HUMPHREY LEGGETT, R.E., D.S.O.

FOURTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 8th, 1920; THE RIGHT HON. LORD CARNOCK, G.C.B., G.C.M.G., G.C.V.O., K.C.I.E., Ambassador to Russia, 1906-10, in the chair.

The following Candidates were proposed for election as Fellows of the Society:—

Cotts, Sir William D. Mitchell, K.B.E., London.
Cryer, A. G., Orpington, Kent.
Duchemin, H. P., Nova Scotia, Canada.
Gösling, Bernhard, Bradford.
Hill, Henry Walker, Nottingham.
Liddelow, Colin Coningsby Watson, Negri Sembilan, Federated Malay States.
McArel, Henry, Nova Scotia, Canada.
Pepys - Goodchild, George William, A.M.I.Mech.E., London.
Stokes, Walter Robert, F.R.A.S., London.
Walker, Sydney Joseph, Sheffield.
Wallis, Percy, Kettering.

The following Candidates were balloted for and duly elected Fellows of the Society:

Attwood, Stanley Herbert, Lincoln.
Fiske, William Grant, Westcliff-on-Sea.
Hutchinson, Gerald Pemberton, London.
Kerr-Jarrett, Hon. F. M., Jamaica, B.W. Indies.
Murray, James O'Hara, M.I.Mech.E., London.
Newell, Edwin Frank, London.
Reed, Engineer-Commander William W., R.N., Portsmouth.
Scott, Robert L., Greenock, N.B.
Scott, Rev. William Stuart, Kenilworth.
Tatlow, Herbert Ernest, Lincoln.
Thomas, Felix J., Woburn, Bucks.
Thomson, Robert, London.

A paper on "A Retrospect of the Personal Influence of Britons in Russia" was read by MR. E. A. BRAYLEY HODGETTS, Chairman, Russian Section, London Chamber of Commerce.

The paper and discussion will be published in the *Journal* of December 31st.

COLONIAL SECTION.

TUESDAY, DECEMBER 7th; THE RIGHT HON. SIR WILLIAM ELLISON-MACARTNEY, K.C.M.G., in the chair. A paper on "Industrial Developments in Australia during and after the War," was read by MR. A. H. ASHBOLT, Agent-General for Tasmania.

The paper and discussion will be published in the *Journal* of December 24th.

JUVENILE LECTURE.

A lecture adapted to a juvenile audience will be delivered on Thursday afternoon, January 6th, 1921, at 3 p.m., by Sir FREDERICK BRIDGE, C.V.O., M.A., Mus. Doc., Emeritus Organist, Westminster Abbey, on "The Cries of London which Children heard in Shakespeare's Time." The lecture will be musically illustrated.

Special tickets are required for this lecture. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

THIRD ORDINARY MEETING.

WEDNESDAY, DECEMBER 1ST, 1920.

SIR CECIL HARCOURT SMITH, C.V.O., LL.D., Director and Secretary, Victoria and Albert Museum, in the Chair.

THE CHAIRMAN, in introducing Miss Pesel, the author of the paper to be read that evening, said she was one of the most skilful exponents of the art of embroidery. He was first introduced to the author a good many years ago when he was living in Athens and Miss Pesel was what he might call the managing director of the admirable enterprise started by Lady Egerton, the wife of the British Minister in Athens, for trying to rehabilitate the ancient art of embroidery in that city. Since that time the author had done valuable work in the north of England in establishing schools of embroidery and was now the President of the Embroiderers' Guild. The very name of "Guild" was interesting to-day, because it took one back to the time when nearly all the arts and crafts of this country were in the hands of Guilds. He thought the principal function of a Guild in these days was to make quite sure that everything that was turned out by the artist or the craftsman was stamped with that standard of quality which was the pride of English production, and there was probably never a time when that standard of quality was more needed than it was to-day, when so many efforts were being made, particularly since the war, to establish centres, especially in connection with wounded soldiers and so forth, where the work was the main thing and where he was afraid the standard of quality was not always preserved.

The following paper was then read :—

EMBROIDERY: NATIONAL TASTE IN RELATION TO TRADE.

By LOUISA F. PESEL,
President of the Embroiderers' Guild.

I feel much honoured at having been asked to address such a distinguished Society, and diffident about putting my point of view before you, as I imagine it may not be shared by all my hearers. At the outset I had better confess that I do not acknowledge the necessity for every craftsman to be a designer, nor, in my own craft, do I believe that all who embroider should only use original designs. I do, however, consider it absolutely essential that all craft workers should study good and preferably old work in their particular craft, until they have acquired a true sense of what is sound and beautiful in that craft. I also think they should gain a knowledge of what generally constitutes good technique and style in other nearly allied crafts. They then make the startling discovery for themselves, a thing much more useful than being told it, that all good craft follows the same general rules fundamentally. They will have added, incidentally, a great joy to life, for they must have learnt to use their eyes to see with and their heads to think with, for they must do so if they make the necessary comparisons. At first most people hate having to use their hands and heads in conjunction, but until they do, they will never excel in any craft.

I hope to-night, with the aid of slides and some modern examples, to show the lines on which both sight and judgment can be trained. I shall take examples from countries where a strong national taste made the work of those countries notable during certain periods. Individual taste always accounts for interesting variations, but the main national characteristics remain dominant.

Some of us feel that enough is not made of national taste here in England. It is rather dormant sometimes. Can we cultivate it more? Could we strengthen it by absorbing the good from the work of other periods and other countries? Should we not be doing useful work if we organised such an experiment? Surely it is a mistake only to study English work. It undoubtedly has its strong points, but it has also its weak ones. If we would make our own modern work strong, we must use all available means. Once a people enjoy doing a thing, they will be found to do it well, and what is well done is usually also done profitably. R.L.S. says: "My idea of *man's chief end* was to enrich the world with *things of beauty* and to have a fairly good time myself while doing so." I think he is right. Work must be enjoyed to be successful. It certainly would be to our commercial advantage, if nothing else, to cultivate and foster a national and individual taste.

Personally, I think this can be done most economically for women, or for the majority of them, by embroidery. The material outlay need not be expensive, its results can be used in house and home, and the difficulty of the work can be increased with the growing skill of the worker. I have seen this education proceeding over and over again during the last ten or twelve years. In many cases the result seemed only a few bits of embroidery; in reality it was a very sound artistic training. This sounds a big contention and difficult. In practice, it is quite simple. Show pupils enough to make them keen and let them puzzle out the rest. Show a little more, and then again leave them to work out things for themselves. Work together, but the teacher must keep at least half-an-hour ahead. It becomes a pursuit, a race, the pupil always trying to catch the so-called teacher. If pupils do beat the teacher, as they often do, she must acknowledge it; it gives the pupil great joy and does not hurt the teacher. Teach pupils to criticise their own work and other work too. Let them learn to know, if a thing is good, why it is good, and if bad, why it fails and where. Once head and hand are working together the main task is done, for a keen craftsman will be developed, and for such an one there are no more "what shall I do hours," for he or she has always something fluid in the brain, waiting to be carried out by the hands, waiting to be completed and finished by the details that only the lover of the work can do to perfection. Writing some 35 years ago, Lady Marion Alford says "Colour, as an art, was born in those lands which cluster round the eastern shores of the Mediterranean—the northern coast of Syria and Arabia and the Isles of Greece. All art grew in that area, and all its adjuncts and materials there came to perfection, though often imported from more southern and eastern sources." The study of the balance of colour adds greatly to the zest of life. It can be pursued anywhere and at all times, and is useful in many occupations, in household furnishing, in planning or buying clothes and in laying out a garden. We do well if we have the chance to follow Lady Alford's suggestion as to where to pursue our study, and if we cannot all do it on the spot, we can all see Mediterranean specimens in our own museums.

Once a good technique has been learnt and balance of colour is understood, judgment as to suitable design soon follows. I say suitable design advisedly, for a design may be good, very good even, for one purpose and yet be bad for another. What is right for a curtain would be quite wrong for a bag.

Technique, craftmanship, colour and its right distribution, and suitability of design, these are the root principles underlying all good work and they are equally applicable to all crafts. They are the base on which all pleasing and satisfactory work is founded.

Later I shall show slides which illustrate these points. I also want to show how strongly race and temperament tell in all handwork. Hunt, in his Talks on Art to his students, says: "You can't help doing your own way. You come here to be shown the way of somebody else. Where's the person that ever did anything without knowing what others had done before him? Why can we talk? Because we are talking all the time." I do not think by seeing what others have done that we shall spoil or hide our own individuality. Once the characteristics of the work of any country or people have been learnt, the subtle resemblances underlying it, seem so marked that it is difficult to understand that they are not evident to all who see it. For example, amongst the embroideries of the Greek Islands there are very marked likenesses, and also some very marked differences. Mr. Dawkins and Mr. Wace, when they were working in the islands, found that those islands which had the same dialect generally had the same embroideries, whilst a different dialect would mean a change also in the style or type of the embroideries. This was a striking confirmation of the theory that a strongly marked type can and does persist over a long period and shows that it has grown gradually out of a united conception. It often persists long, and as it has grown slowly, so also it alters slowly. Sometimes a marked change in type is the result of the imposition of an outside influence. In most cases in the islands it was a foreign conqueror that caused a modification in the style of the work. It is interesting to note the struggle between Oriental and Italian influences in some cases.

So, if we would develop our native taste and make it again a national asset, we must cultivate a fine taste amongst individuals

upon sound general principles. Then our strong good points would become established and so little by little they would become a factor that counted—a factor that marked our products as distinctively British and above the general average in the ordinary market. America, in particular, is anxious to develop an appreciation of good workmanship amongst her people. They have not, perhaps, the advantage of possessing as much old work as we do in England; wonderful old models, both in museums and in private collections. They wish to get good work from this side, and it is for us to produce such things as will show that we possess a fine taste. We must, if we would equal our reputation in the 13th century, produce work worthy of being inventoried not under an individual name, but as English, or, rather, British. In the 13th century the most beautiful copes and vestments were made in the convents. They were given as royal gifts to foreign rulers, and appear recorded for all time as English copes in the royal inventories.

I have referred to our museums as a valuable asset. I wonder if learners, and I think we all need to be so classified, realize how much training they can obtain for themselves by spending all the time they can spare in their Courts, noting design and colour, comparing and examining the exhibits and absorbing the knowledge which the variety of details represents. It is to the Victoria and Albert Museum that I owe most of my training and to the hours I have spent amongst its wonderful cases. I am, therefore a great believer in this method of self training; for it is infinitely more interesting to learn a thing for yourself than to be taught it. It is much more your own when you have worked it out for yourself. A teacher should really only be a signpost to show a pupil where and how to work. A teacher is, perhaps, necessary to help a pupil over the bad places of depression, to explain that all who would achieve great things must constantly be dissatisfied with their own work. One longer experienced in the craft can give help by giving encouragement and by urging the tackling of some difficult task.

It is undoubtedly through tackling the difficult tasks, which seem almost impossible, that one learns the most. May I give a personal example? The round Persian mat exhibited here shows what I mean. I had always worked in colours on a natural coloured linen after the manner of near Eastern work and had learnt their colour balance; reds and blues to balance, brown stems, green for leaves, and yellows, gold and écru for the smaller details. I decided to work on a green background and started gaily with the same colour scheme. I had quite forgotten that these colours would tell differently on the green. Reds showed in too strong a contrast, the blues were lost, and the balance was all wrong. I knew it because I happened to have a cream lining, and it was easy to see the wrong side looked better than the right side. In despair I worked in all the background in creams and gold, and the result was better. I did not regret my worry and despair, for through it I had learnt much which several easy successes would not have taught me. A success is often preceded by much that the worker recognises as failure or partial failure. Failures are necessary to the experimenter, but I think the study of old work appreciably reduces their number, because completed models can be examined at leisure, and the causes both of success and failure can be discovered in the work of others.

Perhaps we do not sufficiently realise how useful it is to develope this power of intelligent and honest criticism. It should be cultivated in pupils from quite an early age, for not only do we need trained workers, we need also future buyers with trained taste.

It is quite possible to put together a red and blue that are beautiful, but, alas, it is also quite as possible to have a red and a blue which are out of relation one to the the other. The trained taste should choose the good combination and reject the bad one, and in time it would be acknowledged that it paid better to supply a thing that satisfied good rather than poor and bad taste.

The subtle differences between good and bad colour can, of course, be studied in other things besides embroideries—porcelain, tapestries, and, above all, really beautiful old carpets. These offer a constant training in colour balance. They all, but carpets in particular, illustrate the value of width and contrast in margins and borders. It needs a very highly trained judgment not to make an error in the width of a border and to be quite sure which colours to repeat in the border; and yet after all it is these difficulties that need to be overcome which

make a craft worth while. If these things could be done without thought, crafts would lose half their charm and interest. It would also mean that the work itself would in a measure lose its attraction, for it would no longer show its individuality. How to finish off work is always a moot point, but it is one which each worker settles largely according to temperament, affected, I admit, to some case by national tradition. So we come back again by another course of reasoning to the fact that work may be individual and that it also is national.

The study of the different types of embroidery and of their marked characteristics is full of interest. It is possible to determine pretty accurately their country of origin and their approximate date. They call for a careful observation of many points, which pass unnoticed at a first casual review. A collection of photographs is a help, as in them likenesses are seen, which sometimes a great difference in colour seems to minimize. In these cases the colour is possibly individual and not traditional. It is helpful to mount them on cards with spaces left for the details and gradually to fill in all details which help in classification.

Before coming to a survey of the work of different countries, I want to draw attention to two big divisions into which embroidery falls, as I think it may make classification easier to the non-worker. For the sake of clearness the two classes might be called (1) geometrical and (2) freehand.

(1) The geometrical classes include all rectangular stitches, cross-stitch and others, which are based upon the warp and weft of the background. The stitches vary in scale according to the quality of the background threads, and the lines of the design are either upright, horizontal or diagonal. The whole of a geometrical or rectangular design is built up by the repetition of small units, the worker starting with a plain piece of material.

(2) In the freehand groups the background has a less important place in determining the quality of the design, because the design is drawn on the background, and is usually planned out before the work is started. Its stitches are decided by the character of the design and not to nearly as great a degree as in geometrical styles by the character of the material upon which they are worked.

The near East developed a *third group*, using the characteristics of (1) and (2). Because they did not wish to count out their patterns, often rather a tedious operation, they drew on a design quite roughly in freehand and then filled it in with square stitches. The result is interesting, for geometrical stitches cannot fail to influence the drawing, and a very angular freehand is developed.

It is a matter of temperament which group appeals most to any individual worker. Some countries specialize in one type, some in another, whilst some countries have both types equally developed.

At the Khaki Handcrafts Club, I found the men much preferred working on the geometrical types. I do not quite know why, unless it was because there is less uncertainty about them. A cross-stitch can only be placed wrongly or rightly, whilst the stitches used in freehand work are generally those in which individual stitchery has more scope, and work can be good, fair or bad.

In examining embroideries, two points must be remembered before making criticisms as to their merits. First, whether they are primitive, peasant or domestic work done for amusement and relaxation often without training or the help of a teacher, or whether they are the work of trained and possibly professional workers, done for sale. The Greek Island work is typical of the first kind, whilst Spanish and English ecclesiastical work comes under the second category. A worker whose trade it is, needs a training that no amateur ever attains. The work of both is needed, but for different purposes.

The second point to be borne in mind is the object for which any given example was produced. Simple work, which is alone suitable for certain uses, often by its wise restraint, shows as much knowledge as an example of great elaboration.

We in England have very little, if any, so-called peasant work. It is, therefore, more difficult for us to make and use the simpler things with no tradition of our own to guide us. It is, perhaps, open to question whether we British, being such a mixture of races, will ever attain a definitely marked type of national taste. In the lesser counties, where the inhabitants are more akin, characteristics would be more strongly marked and show, therefore, more definitely in all work produced by them. The Islands

of Skyros and Crete, both small areas, have work which is strongly marked and definite in type, and in each case quite unmistakably its own. This will be seen on the slides showing the work of these islands.

The slides show some marked national and individual characteristics, and will demonstrate the lines on which I think criticism should be based. I can only give the work of a few countries to-night, the remainder must wait for some of my audience to investigate for themselves. I hope I shall have turned many into much more critical observers.

I wish I could put England as pre-eminently the head of the list. Perhaps we shall do so in another 20 years' time. If we could do so now, I suppose it would hardly be necessary for us to discuss whether we can develope our national taste.

As I cannot claim expert knowledge in either Chinese or Japanese embroideries, I shall not bring them into the discussion. They always seem to me less helpful as models for us Westerners, probably because not being the work of a branch of the Aryan race, they are inspired by a different outlook and desire to express quite other ideas. That is my own feeling only and may not be accurate.

Persian work stands in quite another class, with its beautiful drawing and wonderful clean springy line. It is vigorous, and we ourselves being a vigorous race should find joy in copying it. Compare it with Indian work and you will see what I mean about its strength and vigour. It is, moreover, especially good for us to copy it, for it is often in the drawing of our embroidery that we have failed, and still do fail. When we remember how good are all the other Persian crafts which need beauty of line, we shall see that the Persian considered draughtsmanship a big thing and essential to all good crafts. Examine their pottery and their metal work, their illumination and vellum painting, consider only their carpets, and it will be acknowledged that they could draw. It is probable that valuing draughtmanship so highly, they trained their designers very thoroughly and minutely. Their embroideries appear generally to have been designed by specialists and not by amateurs, for the constructional lines are often the same as those used for tiles and have no appearance of haphazard planning.

Persian colouring is usually simple, and often consists of not more than two or three colours on a white ground. This makes it good as a model. Simple colour must be vigorous and it must be just right.

DESCRIPTION OF SLIDES.

Egypt (Coptic).

The first four slides are examples of work found in the tombs in Egypt. They have been chosen to show that even as far back as the 6th and 7th centuries there existed in embroidery the two main groups of which I have spoken—geometrical and freehand. They are interesting, for they might easily have been the models of much work done, nearly a thousand years later, all around the eastern end of the Mediterranean, that home of colour as an art.

No. 1. A scrap in the Oxford Museum, is a very simple type of *freehand*, and the stitches much the same as we should use if we worked it again to-day.

No. 2. From the Victoria and Albert Museum is also a freehand design and is worked out in wools in chain stitch. It might have been the model for a crewel work curtain worked 30 or 40 years ago. Late Graeco-Roman period, probably 4th-5th century.

No. 3. Is a fine piece of what might be called white pulled or openwork. It is surrounded by a frame work of double running in blue, in which Arabic influence can be seen. It is an example of geometrical work, as the pattern is built upon the linen. It would be coarser on coarser linen—the background controls the scale of the work and the kind of stitches.

No. 4. Is also a geometrical piece, worked in one colour only—blue. Its design is the forerunner of much later work in the Greek Islands. Saracenic from El Azam.

No. 5. Represents a piece worked roughly about 1,000 years later on the Island of Naxos. The stitch is a different one, but still a geometrical stitch. Satin stitch in this example. The design is based on almost the same lines as the Coptic model—a triangular shaped tree detail with birds and a small detail always repeated in between.

Persian.

My admiration of Persian work, as my references will have shown, is very great. Drawing and design, colour and

workmanship, all seem to be so happily blended. I think if it could be arranged, perhaps by the Persian Society, to hold an Exhibition of Persian embroideries it would be a great revelation to many people to whom their beauties are unknown. It certainly would help forward our work a great deal.

No. 6. Is the well-known prayer carpet in the Victoria and Albert Museum, an 18th century specimen. It is on white ground and is embroidered in red and green with white and gold.

No. 7. Is also a carpet, 17th or 18th century. It has a much more open freehand design. The light connecting lines are designed on the same plan as for a tile, and are just sufficient to produce a connected all-over effect. It is worked in a very happily balanced combination of red and blue. The border appears to have been cut and mutilated.

No. 8. Is a border worked in coloured silks and metal thread. It might have been the source of the Cretan borders only that its lines are more graceful.

Fine Turkish Broussa.

No. 9. Is fine Turkish work, usually classified as Broussa. It is on fine muslin, and worked in very fine silks, generally alike on both sides. It is usually very delicate in colour and was worked for towel ends in the harems. The design is freehand, and has more movement than is usual in the general run of Turkish work. Though it is unquestionably Turkish as to nationality, the individual taste is marked.

No. 10. Another Broussa specimen. The corner of a head square. It is a free-hand design, but filled in with geometrical stitch, giving it the square effect of which I spoke.

No. 11. Is Turkish, certainly, and probably Broussa, though it is not so marked in characteristics as the two former pieces. It is much more purely geometrical, and suggests Persian influence. It also reminds one of some Italian work, and helps to prove that certain types of design must always naturally arise from the use of certain materials, and the rectangular lines which have to be followed, because the background regulates the stitches, can only result in certain effects.

Skyros.

Nos. 12, 13, 14, 15, 16. These five Skyros specimens were a portion of a collection of ten or twelve pieces, which were sold in Athens about 15 years ago, after a bad harvest in that island. They were known to have been in the island for 200 years previously. Although the specimens are so different the likeness between them all, in stitch, draughtsmanship and colour is very marked. They are all unmistakably akin and belong to a definite group, and are quite unlike all neighbouring workmanship.

Crete.

Five slides of Cretan work, selected almost at random, show their strongly marked national type. Anyone who has once seen and examined any Cretan embroidery, could never mistake it for the work of any other district. Although the island was often subjected to outside influences, that of Italy in particular, its work still retains its own definite characteristics. It is strong and vigorous, though often, perhaps, a little clumsy. It is handsome and decorative for the purpose for which it was designed—the ornamentation of the women's dresses. It was worked by the women themselves, and the designs, which are freehand, were passed down from mother to daughter. They were probably modified in the constant re-copying, which is most likely the cause of their lack of spontaneity. They were coloured with the idea that they were to be worn out of doors, and in very brilliant sunshine, when pale colours would have been quite ineffective.

No. 17. This shows a cushion, quite typically Cretan, with all its national characteristics. In the middle of the medallion, however, the worker's own individuality crops out most unexpectedly; the couple dancing are quite unusual. I have never seen another medallion like it. They are usually much more conventional. Below is the type of card on which I mount my photographs; it may be of interest to some of my audience, as a suggestion.

No. 18. The usual type of Cretan skirt border worked in the heavy herringbone and other stitches, and in one colour.

No. 19. Is a much more elaborate border, the spaces being filled in with extra [and seemingly unnecessary] detail to give richness of effect. It is a polychrome example.

20. Is an example of what happens when tradition runs riot, and has not a directing mind behind it. It is a hopelessly bad specimen, stiff and rigid in line, with top flowers too heavy for the base ornament.

The border below is, if anything, worse, for it is too wide in proportion, and quite outbalances the filling. Alas for wrong and bad tradition, followed slavishly without any intelligence on the part of the worker!

No. 21. Is a Cretan cushion on the usual and more conventional lines. I have it here to show the colours that are usual, and the type of stitches which are used.

Greek Islands.

To do justice to the different types of work done in the different groups of Greek islands, really Mr. Wace, the Director of the School of Archæology in Athens, should be your lecturer. I shall only say that we must remember that it is the work of Greek Islands, and in most cases was done for their own use, and not for sale. Secondly, I would remind you that it is nearly all done on geometrical lines, that it can be built up on the background, and does not, therefore, need a design drawn on the linen. It is for that reason, I think, peculiarly suitable to be studied by those who either themselves wish to do simple work or who wish to teach others, in village Institutes or elsewhere, to do such work. Once having gained an insight into the methods employed, and the colours that harmonize and give good effects, the worker is able herself to adapt and develop her designs, even if she is not a trained designer with her pencil.

No. 22, 23, 24. Show simple, but effective, cross-stitch borders from the Victoria and Albert collection. They were decoration on dresses, bedsides, cushions, etc.

From the Island of Kos.

No. 25. Is the top of a bed tent, one of the most elaborate pieces, coming from the Islands. It shows the main work done on formal traditional lines, with the curious addition of innumerable personal touches, animals, birds and fancy devices, done as the worker pleased. It is conceivable that they have some symbolical meaning, which we do not know.

26. Shows the Rhodian darning stitch, used on geometrical lines. The shimmer of the silk is made effective by the constant change in the direction of the stitch.

Yanina.

No. 27. Is an example of a big group, commonly classed as *Yanina*. They are all freehand in design and often based upon tile or damask patterns. The stitch is usually a surface darning stitch and the colours a beautiful blue and red, with touches of biscuit, gold and green. It is one of the most sought after kinds of near Eastern embroidery, and any dealer thinks he can get pounds extra out of any collector if he calls a good specimen Yanina.

Spain.

No. 28. Much Spanish work is freehand and looks like trained professional work. It is generally large, bold and strong in good colours. It has sound drawing and is most decorative in character. Its stitchery includes many raised and knotted effects, which give relief and shadow, quite different from the flat smooth stitches of the East, where the shimmer of the silk is used as one of the principal means of obtaining the effect. The example selected here is a portion of a veil on velvet and embroidered in silks and silver gilt thread. It is a beautiful specimen both of drawing and fine workmanship. The proportion of the border in relation to the scale of the filling appears to be extraordinarily successful.

Italy.

No. 29. The first Italian slide is of a table cover embroidered in silks, made in the 17th century, and now in the possession of the Victoria and Albert Museum. It is typical of much old work made in Italy. It is in general lighter in effect than Spanish work, a little more individual, perhaps, in execution, and rather less conventional in design. The drawing has a certain swing in it and is usually good—in this case decidedly good. The Italians were and are particularly clever in designing borders, edgings, fringes, tassels, etc., to complete their work. It was probably the result of their wonderful skill in making lace of all kinds, and it was their way of showing their individual craftsmanship and their special taste.

Nos. 30, 31. Are both said to have come from Greek Islands and yet both specimens are much more Italian than Greek. If they were made by Greeks they were done under strong Italian influence, or perhaps they were done by workers with Italian traditions, living on a Greek island. In either case they show the national Italian type overcoming the Greek type.

No. 30. Is freehand with a square stitch. Italian cross-stitch alike both sides is used for background.

No. 31. Has the design worked in cross-stitch. Its border is just a little clumsier than Italian work is usually, and so it may have been worked by a pupil who had not learnt the Italian balance.

Church Work.

English.

England was in the 13th century noted for her ecclesiastical work and the two examples from the wonderful collection in the Victoria and Albert Museum will, perhaps, just remind some of my hearers to go and examine them afresh.

Syon Cope.

No. 32. The Syon Cope is on a linen ground and is worked in gold and silver thread and coloured silks. The background is worked in silk, which is couched down by a linen thread which is only visible on the reverse side.

No. 33. Is a satin chasuble also embroidered in gold and silver threads and coloured silks. It has evidently not been designed for its present shape, and may have been cut out of a larger embroidery. The spacing of the frame work to the medallions and the subsidiary detail is particularly good, as it succeeds in showing them up and emphasises the fact that the figures inside the medallions are the most important.

No. 34. An important group of distinctively English work are the well-known Jacobean hangings. Their colour is often particularly good; eminently English colouring, what we may see any time when our island dampness gives us wonderful blue-green distances, colour such as we could not imagine originating in an Eastern country with its hardness and its heat. These hangings are, I believe, supposed in their colouring and design to give the effect of one tree against another as seen through a small window.

English—Jacobean.

Hence, I suppose, the varied size of leaves and flowers. Granted this origin, why was it necessary to put them all on one stem or to draw it so much more roughly? With beautiful and original colouring, and often a very highly skilled technique, it seems a pity that the drawing was not more careful or considered. These curtains look beautiful hung in the rooms for which they were designed, panelled in dark oak, and in which they were the only decorative incident. They are, however, not suitable designs out of which to carve a portion to cover a screen or cushion, nor are they suitable to mix with other things in a modern room already full of much miscellaneous furniture. It is a cruel mis-use of an old model.

No. 34. Is a wonderfully fine piece both for colour and craftsmanship.

No. 35. Shows the unsuccessful restless stem.

No. 36 Is more balanced, because its stem is made more subsidiary to the rest of the design.

Black Work—Tudor.

36, 37, 38. Two beautiful and very finished specimens of black work, and an Elizabethan garment, are the last slides I shall show.

The black work introduced, it is said, by Catherine of Aragon, is from the craft point of view, some of the finest existing. The designs are good and suitable, and are filled with detailed stitchery of the most excellent technique. The workers must have studied their art most carefully to achieve such a mastery of it, and to have discovered how to balance their light and dark stitches so successfully. The lack of colour is not felt: in fact, the addition of colour would spoil the beauty of the effect.

No. 37. The addition of metal thread in some specimens is also a great achievement.

No. 38. An example of the Elizabethan dresses and tunics. Their definite character is strongly marked, the designs were made for the special purpose for which they were required; they were kept on formal and conventional lines, and the workmanship and colour were careful and restrained.

I hope the slides and my short explanations will have proved sufficient to show that old work is worth consideration, and that, if we study it intelligently, we shall improve our own work. I have the honour to be President of the newly revived Embroiderers' Guild. We hope to unite professionals and amateurs and all who are interested in making this old craft alive to others, all those who are teaching in the many Women's Institutes up and down the country, teaching Girl Guides and Y.W.C.A. classes; in fact, all who teach embroidery anywhere. Under one common guild we hope to learn together on common lines. We shall organize lectures and exhibitions, classes and informal talks in order that we may gain, and then spread, knowledge. That

is the true secret of success—get, then give; so only does the circle increase, always to pass on what has been learnt. It was on these lines that three highly successful needlecraft Associations were run up in the north, and it is on these lines that work must now be done over a larger area. If all here to-night will give us their interest and backing, we shall soon become strong. If they will lend us their treasures for small exhibitions, they will feel they, too, are helping in the work of making us a nation keenly alive to all that is beautiful; a nation able on artistic grounds, to compete with all comers, and fitted to lead in these difficult years of re-construction.

DISCUSSION.

THE CHAIRMAN (Sir Cecil Harcourt Smith, C.V.O., LL.D.), in opening the discussion, said he was sure everyone present had been deeply interested in the extremely suggestive points of view that the author had put forward not only in her paper but in the slides she had shown. The author had made frequent references to the Victoria and Albert Museum, which contained what he believed to be an absolutely unrivalled collection of textiles. And here he would like to state that the Museum authorities made a point of discouraging copying. The essence of the function of the Museum they regarded as being inspiration and not the provision of models. They did not want people to come to the Museum to copy; they wanted them to come and impregnate themselves thoroughly with the spirit of the good traditions and reproduce them, allowing scope for their own individuality. One of the things that had interested him very much on the present occasion was to see specimens of work by two mistresses of the art of embroidery, Miss Pesel and Mrs. Newberry, which showed the way in which the inspiration of the Museum could be adapted to the production of really good work to-day. With regard to the question of design, he thought it was most important to consider what purpose the design was intended to fulfil. In the mid-Victorian period it was quite a common thing to see hearthrugs with such designs as a woolwork lion in a wreath of moss roses, but we had got past that kind of thing now. There were two points that it was important to remember in connection with design. One was whether the design was to be seen always as a flat piece or not; for instance, whether it was to be used in a hanging fastened flat upon the wall or in a curtain. If a figure subject was chosen where only a portion of the design was going to be seen at one time, there was a risk of only half a figure being seen. There was an illustration of that on the tube railways, where a great number of posters were pasted up on the curved surface of the walls, sometimes even interrupted by a moulding, so that the figure of a very beautiful damsel could be seen with her chin resting on her knees. The second point to be remembered in connection with design was the question of balance. He might say, in regard to balance both of colour and of design, that when people went to such a place as the Victoria and Albert Museum they should exercise their own judgment; there were exhibits shown there which were of extraordinary interest from the point of view of technique but which were not desirable things to copy from the point of view of design. In the north and south courts of the Museum at the present time, there was a wonderful loan exhibition containing perhaps the very finest Bayeux tapestries in existence, belonging to the Duke of Portland, and they were an illustration of what he meant. They were absolutely marvellous imitations of pictures An old writer of the sixteenth century, who wrote very charming poems about the embroideries of the time, pointed out that the embroiderer had the skill of the painter and nothing was too difficult or too diversified for him to reproduce with his needle. That was of course the criticism of a poet and not a desirable one to follow. He supposed it was a commonplace to say that the great tapestry fabrics of the eighteenth century began to decline when they entered into competition with the painter: the needle must never enter into competition with the brush. He did not know whether any of those present had attended a series of discussions which took place last spring as the result of a very extraordinary discovery by a young Canadian architect and mathematician, Mr. J. Hambidge. He firmly believed that Mr. Hambidge had solved, or at any rate had gone a long way towards solving, a problem that had been passed down to us through some of the greatest minds of ancient and modern times, a problem that had vexed the philosophers of Greece and had vexed Leonardo, *i.e.*, the real secret of proportion. Mr. Hambidge had shown that all good proportion was based upon nothing more or less than a geometric progression, and had given a full disquisition of his theory in a magazine which he edited himself, called "The Diagonal." Personally, he thought it was one of the most remarkable discoveries from the point of view of art that had taken place in modern times, because it gave the law underlying proportion. It was the first time an attempt had been made to give a definite law of proportion, which must obtain naturally in every kind of design, whether in textiles, architecture, or anything else, and the extraordinarily interesting point about Mr. Hambidge's discovery was that the law he professed to have discovered was the same law which he found obtaining in the simplest creations of Nature. With regard to the

balance of colour, personally he thought there was a law of the balance of colour just as there was a law of the harmony of music. Sooner or later it was certain to be found that there was an alliance between the balance of proportion, the balance of sound, and the balance of colour. He did not know whether it was an actual fact, but he had been told that a firm of textile designers in the City employed a lady who either possessed by nature or had achieved by art an astonishing capacity of translating into musical notation any scheme of colour that was shown to her. When a coloured design was submitted to her she was able to play it over on the piano and to tell at once whether that scheme of colour was in harmony or not. Whether that was true or not, there was no doubt that we were on the way to making very extraordinary discoveries in that direction. One other point he wished to mention was the individuality of English art in textiles as in other things. He did not think the author in her desire to show how beautiful Oriental and Near East embroideries were, gave quite sufficient credit to English art. He thought there was nothing finer, either in the way of colour or in the way of design, than some of the late Tudor and early Jacobean textiles. It always interested him very much to see how far nationality—what the author called "group production"—really was an index of colour. In going through the Spanish Exhibition at the Royal Academy he noticed three phases in the pictures there. First there was the strictly ecclesiastical phase of Spanish painting, when the pictures were hardly to be distinguished from those of Italy, the early Middle East school and so on; secondly, there was a vast mass of Spanish painting which was very homogeneous both in tone and in colour, and, so to speak, in spirit; and thirdly, there were the modern Spanish paintings, which might just as well have been painted in Paris. As the author had pointed out, the Mediterranean countries generally produced bright colours, and it had always struck him as rather odd that, although Spain was to all intents and purposes a Mediterranean country, the colours of the great bulk of the Spanish paintings were extraordinarily sombre, and he wondered sometimes whether colour was really a question of climate or not. English colouring had always been of a very marked character. At the Victoria and Albert Museum there was at the present time, through the kindness of the Dean and Chapter of Durham Cathedral, perhaps the most remarkable collection of Early English manuscripts existing in this country. Some of those manuscripts had an extraordinary interest as showing what a peculiarly individual type, both of design and of colouring, obtained in England in the twelfth, thirteenth and fourteenth centuries. Perhaps the most splendid example of that were the Lindisfarne Gospels in the British Museum. The author had spoken about individuality and the survival among the Greek Islands of the strictly group types of design, and he fancied that at one time there was a great deal of work peculiar to England carried out all through the English counties. One example of that was the old smock. The old smock frocks worn by the shepherds and agricultural labourers in this country had all their own individual patterns, and he believed that the different counties had their own special patterns. The authorities at the Victoria and Albert Museum had been trying to collect specimens of them simply as an historical record and he hoped if any of those present came across any such survivals of the past they would try to secure them for the national collections, because it was most important that those relics of an extraordinarily interesting textile past in England should be preserved.

MR. A. F. KENDRICK (Department of Textiles, Victoria and Albert Museum), said that if the paper had been read about twenty years ago the author would probably have dealt chiefly with English work, but he thought she did quite rightly and very wisely in drawing particular attention to foreign work, for this reason, that whereas twenty years ago people did not care at all for English work and always thought that they should devote themselves to studying foreign work, when the reaction came they might be inclined to go too far in the other direction. But, for all that, our own national art must retain its own national characteristics, and it was an interesting fact that if a party of English people were taken to a representative collection they somehow gravitated towards the English work. With regard to the embroidery done by soldiers, he thought it was time that a word of caution was uttered in that respect. There had been an enormous amount of well-directed zeal and care given to the work of teaching embroidery to disabled soldiers, and that work had been of very great value, because it had provided a restful form of amusement to men in Hospital and had given them something to do, but they should not make the mistake of thinking that they could now make a living by it. The number of well-trained and capable women and girls was quite sufficient to meet the demand, and it would be well to realise that fact before it was too late.

MR. ALAN S. COLE, C.B., said he did not agree with Mr. Kendrick that English embroidery was not much appreciated twenty years ago. He had been connected with the Kensington Museum and also with the Science and Art Department, and it was just about twenty or twenty-five years ago that some extraordinarily good pieces of English embroidery were sent up from students at schools of art, or schools of needlework connected with them, at Birmingham, Glasgow, and other important places. Those exhibits received the highest commen-

dation from the then competent authorities, including such men as William Morris, Walter Crane and Lewis Day. With regard to the organisation of needlework, during the last seventy years a number of schools of art had been founded all over the country: traded taste had made very great progress. He remembered that about fifteen years ago he delivered a lecture upon the means of identifying various styles of embroidery, and at that time he laid a good deal of stress upon the aesthetic side of pattern making, the evolution of pattern, and so on. He did not think much could be done in the way of classifying patterns by nations, as they were now so intermixed. The British Isles were subject to cosmopolitan influences from all round, and he did not know where one could point to precise features of what was English. Even the work (*opus anglicum*) done by mediæval English Communities could not be called English work in the true sense, *i.e.*, work done in England by English people, because there was a number of French and other foreign brethren working in the monasteries of this country at that time.

Mr. Arthur Wilcock said it had been a great pleasure to him to listen to the paper, and he had learned a great deal from it. With regard to the question of taste, education was the only thing that would be of any use, and the easiest way was first of all to approach the salesman, the man who came into immediate contact with the public. It was also very important that the buyer should be educated, because he bought the articles that he thought the public wanted. With reference to the author's criticism of the Jacobean worsted work, that particular work had always had a great charm to him, because it seemed so thoroughly English in its interpretation of the Oriental. In the whole of the Victoria and Albert Museum the most interesting exhibits to him were the English ones, right through the centuries from the thirteenth, when this country was pre-eminent in the art of embroidery.

Mr. H. L. Hobbs (Messrs. Thomas Martin and Co.) wished to say a few words from the strictly practical point of view. Although the title of the paper was "National Taste in relation to Trade," the subject had been dealt with from the point of view of excellence of craftsmanship only. When looking at the subject from a trade standpoint, excellence of workmanship was by no means the only point to be considered. A perfectly executed piece of work was necessarily an expensive one; therefore such work had a decidedly restricted market, and because of that could never form any great part of the trade or employ any great number of workers. Personally he was in the art needlework trade, and therefore he was speaking from a strictly trade point of view, which was possibly a different point of view from that of the majority of those present. Indicating one of the panels exhibited, Mr. Hobbs asked the author how many hours were occupied in its execution. If she could give that information, he would leave it to the meeting to arrive at an idea of the price that it would have to be sold at, and then they would be able to form some opinion of the volume of trade that could be induced at such a price and of the possibility there would be of developing an industry on any considerable lines at such prices. He was not decrying the best work; they would all like to do the best work. Mr. Wilcock said that the buyer needed education, but the buyer was hampered at every step by the price that the public was willing to pay for the goods.

Prof. P. E. Newberry said that twenty years ago he was asked to organise for the Royal School of Art Needlework at South Kensington an exhibition of embroideries of the Nearer East. He collected some 300 or 400 different pieces and showed them at the School, but none of the Committee or the teachers of that School would look at the pieces. When he took round one of the most distinguished members of the Committee of the School to show her the embroideries, she picked out one of the most ugly pieces of work he had ever seen from the Nearer East, a piece of green satin with gold embroidery on it, as being the most beautiful in the whole exhibition, although he had there some of the very finest pieces of Yanina and Rhodian and Persian work. He had to admit that he was very much disappointed at the taste displayed by those people twenty years ago. He had listened with very great interest to the paper and had learned a great deal from it. With reference to the pieces of work by Mrs. Newberry that were exhibited at the meeting, most of them were not absolute copies of the original but had been adapted from pieces either in their own collection or in the Museum at South Kensington. He agreed with the Chairman that in the question of design it was important to consider whether the work was going to be placed flat or in a hanging position, and said that some of the exhibits should be looked at as a rug or carpet lying on the floor. He would like the author to give some information about the Yanina embroideries.

Mr. Thomas Muddiman said he agreed with the author that it was not always wise for the designer to carry out the work of embroidery. A good worker would work to the exact design and often do better work than the designer herself would do. From the point of view of commercial production it was better for a designer to give her time entirely to designing, because she could then turn out a larger quantity of designs. In the commercial side of embroidery public taste had to be considered. If he did not follow the public taste and turn out what the

public would buy, he would soon lose his trade. If the manufacturers could afford to have better designers they would have them, but the public would not pay the price. The reason why manufacturers were not able to spend their time on the kind of work that was exhibited at the meeting was because of the public taste. He thought the exhibits were most beautiful and did the workers an immense amount of credit.

THE CHAIRMAN said that Mr. Hobbs and Mr. Muddiman had raised a very important question, namely, the extraordinary difficulty of producing the best work at a price which brought it within the means of the general public. The public had to be educated and the buyer had to be educated. On that point he thought it would be very interesting to hear the views of Major Longden, the Director of the British Institute of Industrial Art, because he had had a great deal of experience lately in going between the manufacturers, the buyers, and the public.

MAJOR A. A. LONGDEN, D.S.O. (Director, British Institute of Industrial Art), said it was very interesting to hear Mr. Muddiman's point of view, because at the recent Exhibition of the British Institute of Industrial Art, by far the most interesting trade embroidery sent in was from that gentleman, who got a tremendous amount of variety in his work, not only as regards colour but as regards technique. He had recently been through a great deal of the machine-made embroidery in Macclesfield and in Nottingham, and it was appalling to notice the lack of inspiration in the work, through no fault of the workmen. Such work need not always be uninteresting; it was quite possible to make it interesting and cheap. When the lecturer spoke of a portfolio going round from member to member of her Society, he wondered if it was not possible to go one better and help the various manufacturers of embroidery by causing such designs to be brought before the people who were actually engaged on this work in the trade. He had talked to the workers themselves. They were too busy all day and, in nine cases out of ten, far too tired at night to attend an art school, and many of them said that even if they did attend an art school they found a lack of unity between the art teaching and the machine. He was not criticising the schools, but merely quoting what was said to him. It was, however, perfectly true that they knew a great deal more about their trade, and they did not find it worth while going to an art school either to copy an old design they could not reproduce on a machine or to listen to a man talking on architecture. If, after considering all the conditions of the trade and with the help of the lecturer, the Chairman and others, some kind of system, such as he had suggested, could be developed, a very great deal could be done for the country as a whole, as had already been done in Norway, Sweden and elsewhere. In certain districts every school should be fitted with the latest forms of machines, and the best brains brought to bear upon the possibilities of such machinery, with a view to creating new motifs, and getting away from the everlasting festoon, sway and sprig.

MISS L. F. PESEL, in reply to the question asked by Mr. Hobbs as to the length of time a certain piece of work had taken her to do, said it had been on her hands for about ten years; the war had intervened and she had done very little at it for some time then. She had done it as a relaxation and experiment. There was about £15 worth of work in it, reckoned at one shilling an hour. Frankly, she did not think a large piece of work ever paid, but the people who carried it out learned a great deal which did not come on the paying side. A great deal of such work was done for one's own use and for the sake of the training it gave one in colour and accuracy and many other things, and she thought the training thus obtained in private work should be utilised for trade productions. The people doing trade work probably could not gain such experience because they had not the time to give to it, and she thought the experience of the amateur who had given a great deal of time to the matter would be very useful to add to the knowledge of those engaged in trade. She thought her criticism of English work had been taken by some of the speakers not quite in the spirit in which she meant it, or possibly she had not made herself clear. She admired the English work enormously, but did not think it would teach people much about design and colour. She advocated going to the East to learn about colour because they knew all about it there, and one ought to go to the masters of colour to study it. She had spent four years in Greece, and had obtained her training in that way; that might not be the only way to obtain the training, but she advocated it as a useful method of learning colour.

MR. F. W. LONG said what was needed was to create a demand for better work. If a piece of work like the specimens exhibited was produced, a man might keep it for three or four months before he sold it, and what he wanted to do was to sell things by the dozen, as it were. He believed there were workers in the country quite capable of producing work as good as that which had been produced in the past, and such work might be done to-day if the people who had the money to buy it could be educated to appreciate it and purchase it. It was a very awkward position: manufacturers would like to produce the work but they could not sell it. He would much prefer to do good work rather than the ordinary class work. If people would demand good work there would be a great improvement seen in art embroidery.

THE CHAIRMAN, in moving a hearty vote of thanks to the author, said both the paper and the discussion had been most interesting. He thought everyone would agree as far as the discussion had gone that the question was really one of education. The public and the buyers who led the public taste had to be educated. It was especially necessary that the buyers at the various large establishments should be educated, because they were the "go-between" between the public and the manufacturers. That movement had begun already, as there were classes for the intermediaries held, for instance, at the London County Council Central School of Arts and Crafts and elsewhere.

The resolution of thanks was carried unanimously and the meeting terminated.

GENERAL NOTES.

INSTRUCTIONAL FACTORIES.—According to the Minister of Labour, Dr. Macnamara, on October 26th, there were 55 instructional factories and large workshops in which ex-service men were being trained, the total number of places being 18,072. At that date there were 7,460 men in training in these centres, which number has now increased to over 8,000 and is still increasing. The cost of allowances to men in Government instructional factories is at present approximately at the rate of £1,100,000 per annum, and the cost of training them is approximately at the rate of £1,150,000 per annum, excluding any charge for interest or depreciation on capital assets. The total number of man in training with employers in technical institutions, and in Government instructional factories is approximately 25,000. The waiting list at present is 17,000. The normal cost of training a man is £300.

SPANISH TANNERIES.—The tanning industry of Spain is of some importance, although scattered among a large number of small tanneries operating very much in a rut and with small forces. In all Spain there is not a tannery that has a technical director or a chemist, and the old process of tanning skins for soles and kips is still practised. Before the war there were about 1,500 plants, with a total of 100,000 workmen. Since the war, tanneries for chrome tanning, especially of goatskins, sheepskins, and calfskins (box calf), have multiplied, but they have not attained the standard of perfection set by the foreigner, as there are no modern plants supplied with all the modern machines. During the war, machines were introduced. Before that time the machinery for the manufacture of sole leather consisted only of a cylinder to calender the leather. The rest of the labour was manual and routine. The use of drums (bombos) developed only a little before and during the war.

LUMBER TRADE IN ARGENTINA AND PARAGUAY.—The Argentine-Paraguayan Industrial Lumber Co., has announced a policy of general development of the native lumber trade combined with a scheme of colonisation of their lands. The Company now has three sawmills in the Territory of Misiones and another in the city of Buenos Aires. They have confined their activities to the production of lumber and boxes for packing houses. Logs have been made into rafts and floated down the Parana River, a distance of 800 miles to Buenos Aires. Now the company plans to increase the extent of its lumbering activities and to develop the actual manufacture of boxes, casks, wooden houses, and even wooden ships. Later it is intended to exploit the medicinal plants and dyewoods found in the Misiones region. As the land is gradually cleared, the company plans to attract immigrants there, since Misiones is well adapted to the cultivation of cotton, yerba maté, tobacco, peanuts, and fruits.

USE OF PEAT AS FUEL ON SWEDISH RAILWAYS.—Interesting trials to test the possibilities of peat as fuel for locomotives have been in progress for some months on several railways in Sweden. The reports, according to the American Consul General at Stockholm, so far show favourable results. One privately owned railroad in southern Sweden, 412 kilometers (256 miles) in length, has found peat so practical for steam purposes that the management believes the road can dispense entirely with coal. The state Railways have likewise been testing peat for steam purposes, with good results, and have on a limited scale adopted it for fuel. For some years the State Railways have been operating a factory for the production of peat powder, which is said to make an excellent fuel. In Sweden, where there are 10,000,000 acres of peat bogs, with an average depth of 6.6 feet, the substitution of peat for coal would add enormously to the national wealth. Every acre of peat bog yields nearly 1,000 tons of prepared peat.

MANUFACTURE OF PAPER PULP IN KONGO.—Papyrus, which grows in great abundance near Elizabethville, in the Belgian Kongo, principally along the lower Lualaba, near the lakes of Kabuli, Sjemba, Kisali, and Neaga, is to be exploited by a large company which has been granted a concession. The American Consul General at Brussels, states that it is planned to establish near the river a large plant, costing two and a half million francs, which will have an initial production of 20,000 tons of pulp. The material for this factory is to be sought among Belgian and, if necessary, allied manufacturers. The papyrus of the Kongo has shown on analysis to contain 37.8 per cent. of cellulose. After research and experiments, a process was discovered for bleaching the plants which had been vainly sought for 50 years.

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FRIDAY, DECEMBER 24, 1920.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

COLONIAL SECTION.

On Monday, January 3rd, at 5 p.m., a paper (illustrated with original lantern views) on "The Alluvial Diamondiferous Deposits of South and South-West Africa," will be read by MR. FRED. C. CORNELL, O.B.E. The chair will be taken by MAJOR SIR HUMPHREY LEGGETT, R.E., D.S.O.

FIFTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 15TH, 1920. COLONEL GEORGE LOYD COURTHOPE, M.P., President of the English Forestry Association in the chair.

The following Candidates were proposed for election as Fellows of the Society:—

Aspden, Ralph L., Chorley, Lancs.
Braddock, Geoffrey Frank, London.
Creed, Frederick George, Croydon.
Cuthbert, The Hon. Sydney, Belize, British Honduras.
Mackey, Prof. William Thompson, Ph.D., Washington, D.C., U.S.A.
Pittard, Major William Ebenezer, Southampton.
Pye, James, Burton-on-Trent.
Selson, Henry Maxwell, Gerrard's Cross, Bucks.
Staiti, Henry T., Houston, Texas, U.S.A.
Tyler, Alfred G., London.
van Santvoord, Seymour, Troy, New York, U.S.A.
Williams, Thomas Elson, Watford.

The following Candidates were balloted for and duly elected Fellows of the Society:—

Bray, Richard, Malaga, Spain.
Goldstone, Meyer H., Southport, Lancs.
Lamberton, Hugh Alexander, Pollokshields.
Liversidge, Ernest, Dewsbury.
Richardson, John Seagram, London.
Sharples, William Ellison, A.M.I.M.E., Chester.
Thompson, Errol H., B.A., Sunderland.
Ticehurst, Hugh Gorham, Bexley Heath, Kent.

A paper on "Forestry" was read by MAJOR-GENERAL THE RIGHT HON. LORD LOVAT, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O.

The paper and discussion will be published in the *Journal* of January 7th.

SPECIAL MEETING.

FRIDAY, DECEMBER 17TH, MR. OLIVER BURY, M.Inst.C.E., in the chair. A paper on "The Breeding of Sheep, Llamas and Alpacas in Peru, with a view to supplying improved raw material for the Textile Trades" was read by COLONEL ROBERT J. STORDY, C.B.E., D.S.O.

The paper and discussion will be published in the *Journal* of January 14th.

CANTOR LECTURES.

On Monday evening, December 20th, MR. A. CHASTON CHAPMAN, F.R.S., F.I.C., delivered the third and last lecture of his course on "Micro-Organisms and some of their Industrial Uses."

On the motion of the Chairman, DR. M. O. FORSTER, F.R.S., a cordial vote of thanks was accorded to Mr. Chaston Chapman for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

JUVENILE LECTURE.

A lecture adapted to a juvenile audience will be delivered on Thursday afternoon, January 6th, 1921, at 3 p.m., by SIR FREDERICK BRIDGE, C.V.O., M.A., Mus. Doc., Emeritus Organist, Westminster Abbey, on "The Cries of London which Children heard in Shakespeare's Time." The lecture will be musically illustrated.

Special tickets are required for this lecture, and no person can be admitted without one. A few tickets are still left, and these will be issued to Fellows who apply for them at once.

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

Tuesday, December 7th, 1920.

The Right Hon. Sir William Ellison-Macartney, K.C.M.G., in the Chair.

INDUSTRIAL DEVELOPMENTS IN AUSTRALIA DURING AND AFTER THE WAR.

By A. H. Ashbolt,

Agent-General for Tasmania.

In view of the absolute necessity for all parts of the British Empire to understand what is going on in the different countries comprising that Empire and so enable those who have its welfare at heart to assist in consolidating the component parts, I am endeavouring in this paper to assist that object by giving some information as to the manufacturing developments in Australia and the future possibilities, so that these opportunities may be utilised by Britishers (in which term I, of course, include Australians themselves) rather than by aliens.

In the first place, I want to impress upon the people of Great Britain the fact, which the great war emphasised, that owing to Australia's distance from the more largely populated continents, it is essential for its own protection that the country should be made as nearly as possible self-contained.

To-day there is no question in Australia as to whether the future policy is to be Free Trade or Protection. For good or ill, Australia is wedded for all time to the ideals of protection, and whilst the tariff is in many instances a revenue rather than a protectionist measure, it is a definite policy that where new industries are established, and give evidence of their ability to supply considerable quantities of Australia's requirements of any kind, the tariff will be altered so as to give sufficient protection to that industry.

Both employees and employers are at one in their views on this point, and even those engaged in pastoral and agricultural pursuits accept that dictum, notwithstanding the fact that in many cases it means for them a higher price for their machinery and implements. The net result is that the percentage of imports into Australia from overseas is becoming a diminishing factor, a point of considerable interest to British manufacturers, inasmuch as up to the date of the War they supplied 60 per cent. of the goods imported by the Commonwealth.

Instead of the Australian Continent becoming—as population increases—a larger importer of British goods, the reverse will be the case as more and more of her own requirements are produced in the country.

In the interests of the Empire, the developments that are taking, and will take place, in Australia should be by Britishers, and my justification for this paper is the attempt to induce British manufacturers who for many years have been supplying goods to the Australian market to recognise what may be an unpalatable fact, and instead of letting the business go by the board put their heads together, and, in association with Australia, erect branches of well-known British businesses and so produce there those British goods which have been supplied from the Homeland and which have deservedly earned such a high reputation.

Now, in what lines and to what extent have Australian industries developed? Comparison of the years between 1909 and 1917—the latest period for which official records are yet obtainable—shows that from pure necessity considerable industrial developments occurred during the War, owing to British factories being required almost solely for war work, together with the fact that the steamers were withdrawn for transport and other purposes. This meant that Australia was entirely cut off from the source of previous large supplies. For immediate wants she turned to the United States of America and Japan, but simultaneously set about organising new industries, reorganising and extending existing ones, notwithstanding that about 450,000 men who enlisted in the Army greatly reduced available labour. To compensate for this, machinery was largely imported from America, with the result that the output doubled in value, and although this value was inflated by increased prices, such increase was nothing like as high in Australia as in the other centres of the world. There is no doubt, therefore, that the actual increase in output in quantity was in 1917 at least 50 per cent. more than in 1909. The actual figures are as follows:—

Year.	No. of Establishments.	Hands Employed.	Salaries and Wages Paid.	Value of Plant, Land, Machinery and Buildings.	Value of Materials used.	Value added by Manufacture.	Total Value of Output.
1909	13,197	266,405	£21,105,456	£54,622,672	£64,028,881	£41,929,447	£105,958,328
1917	15,179	321,670	£36,618,218	£90,528,300	£132,283,096	£74,103,550	£206,386,646

Since 1917 the actual quantity and value of output have been considerably increased, as it was not until towards the end of the War that some of the expansions and new concerns really got into stride.

A comparision of exports between the years ending December 31st, 1913, and the twelve months ending June 30th, 1920, is as follows:—

Total exports beyond Australia for 12 months ending:

Dec. 31st, 1913.	June 30th, 1920.
£78,523,769	£112,000,730

The bulk of these exports was naturally the product of primary, not manufacturing, industries, and comprised largely foodstuffs, wool, etc., the actual percentage of manufactured goods exported being small.

British manufacturers will probably want information as to the lines most likely to be affected by the policy indicated. A study of the statistics of imports for the year ending December 31st, 1913, and the year ending June 30th, 1918, will give some information on this point. The figures are as follow—

Classes.	1913.	1918.
	£	£
Animal foodstuffs, etc.	947,697	1,080,249
Vegetable foodstuffs, etc.	3,315,825	1,930,247
Beverages, (non-alcoholic), etc.	1,833,235	1,843,990
Alcoholic liquors, etc.	2,095,896	1,445,217
Tobacco, etc.	1,114,949	646,746
Live animals	145,215	88,316
Animal substances, etc.	417,039	508,527
Vegetable substances, etc.	1,344,204	3,114,991
Apparel, etc.	19,705,768	21,824,720
Oils, etc.	1,969,628	2,996,478
Paints, etc.	609,859	423,397
Stones, etc.	218,332	131,648
Specie, etc.	377,220	76,003
Metals (manufactured) ores, etc.	1,575,734	221,030
Metals (partly manufactured)	1,500,436	477,862
Metals (manufactured)	16,623,135	7,966,937
Leather, etc.	1,749,046	1,643,647
Wood, etc.	3,573,753	1,697,836
Earthenware, etc.	1,580,615	781,978
Paper, etc.	3,134,750	3,003,538
Jewellery, etc.	1,410,555	1,065,432
Instruments, etc.	754,589	701,420
Drugs, etc.	2,493,192	3,217,933
Miscellaneous	11,258,981	3,934,022
	£79,749,655	£60,822,164

The main imports will be seen to comprise textiles and machinery, and it is principally in these two classes that future Australian manufacturing expansion will take place.

Some detailed information of what has been done in the direction of industrial

expansion during the last few years should be of interest.

Iron and Steel Production.

The history of the world shows that the dominating factors in industrial progress are iron and coal. The fact that Australia possesses these two essentials is bound to increase her power and position as the years go on, more particularly when it is borne in mind that the iron deposits of America, Germany and England average under 50 per cent. of metal, whilst the deposits in Australia and Tasmania run between 60 and 70 per cent. With modern plant and the same equal rates paid now for labour, Australia will very shortly be in a position to export pig iron in competition with any part of the world.

It is not necessary for me to enlarge on the importance of the coal industry of New South Wales; suffice it to say that in addition, there are in other parts of the mainland and Tasmania proved deposits, some of them little worked at present, but of an extent which remove all question of any failure in this most important factor.

It is in iron and steel and allied works that the greatest advances have been made. The following figures show the rapid decrease in imports of some of these lines, the decrease, of course, having been more than made up by local manufacturers:—

	1912. Tons.	1917. Tons.
Pig iron	43,642	2,250
Bars, rods, angles, etc. ..	145,506	17,780
Blooms, solids, scrap, etc.	31,169	217
Wire	81,658	19,109

The primary reason for this big diminution of imports is the establishment of the works at Newcastle, New South Wales, by the Broken Hill Proprietary Company, together with the extensions made by Messrs. Hoskins and Company to their plant at Lithgow. The decision of the Broken Hill Proprietary Company to establish iron works at Newcastle and the erection of this plant came at a most opportune time, and no factor contributed to the ability of Australia to keep itself supplied during the war period more than this undertaking.

As an indication of the magnitude of the Company's operations at Newcastle in New South Wales, the Iron Knob in South Australia and limestone quarries in Tasmania, it may be mentioned that some £3,500,000 have been expended. The works at Newcastle comprise blast furnaces with capacity of 1,000 tons of pig iron per day. The steel production is estimated at 25,000 tons per month, or about 300,000 tons per annum.

Open Hearth Steel Production.

The bloom and rail mills are capable of producing from 130,000 to 150,000 tons per annum. Other mills produce ordinary structural iron, etc., totalling about 100,000 tons per annum. Constant extensions are being made to the plant to increase the capacity as well as the variety of goods turned out. Consequently all industries requiring iron or steel can rely upon adequate supplies from the two existing sources mentioned, and there is no doubt that the energy and foresight of these two companies have revolutionised the general manufacturing possibilities of the Commonwealth.

Machine Tools.

The bulk of machine tools used in Australia are obtained from Great Britain and the U.S.A. It is one of the industries which offer great possibilities to British manufacturers. My suggestion is that the leading British firms should get together and jointly work a large modern plant in Australia or Tasmania, where they could in their joint interests produce the best tools of the group's output and so save the perpetual expense of selling half a dozen machines or tools of slightly different designs to do the same work. The Joint Committee could soon determine which of the manufacturing group's products was most suitable for Australian requirements, and the Australian factory could then concentrate and standardise the output to meet the demands. The saving in stocks of spares alone would more than justify the arrangement.

Sewing Machines.

At present all sewing machines used in Australia are imported, but the Australian Government are endeavouring to interest sewing machine manufacturers to establish this industry in Tasmania. At the present time there is no duty on British sewing machines. For other countries the rate is 10 per cent. On and after January 1st, 1922, the duty ceases existing, and a fixed rate of £2 10*s*. per machine is imposed upon those of British manufacture and £3 10*s*. upon those of foreign manufacture.

The number of sewing machines imported into Australia is close on 50,000 per annum; consequently here is an industry waiting for British enterprise, with full

protection provided for those who accept the possibilities and the commercial risk attached thereto.

Ship Building.

Until the establishment of the Broken Hill Company's works at Newcastle, shipbuilding on any extensive scale in Australia was almost impracticable, but to-day practically every part of a vessel can now be supplied by Australia. with the exception of some of the largest plates, and it is now only a question of a short period before these also will be available. The Commonwealth Government themselves are now ship owners and have placed orders in Australia for a considerable number of first-class vessels. The following are the yards at present engaged in ship construction in Australia :--

The Federal Government Naval Yards at Cockatoo Island, Sydney.

They have already completed four 5,000 ton D.W. cargo vessels, and are now engaged upon two 12,500 tons D.W. passenger and cargo vessels.

The Federal Government Ship Building Yards at Williamstown, Melbourne.

Are building four cargo steamers of 6,000 tons D.W. capacity, the intention being to keep these yards fully employed for some considerable period for the construction of this sized vessel.

The New South Wales Government Yards at Walsh Island, Sydney.

Are constructing three 6,000 and three 5,000 ton steamers on behalf of the Federal Government.

Poole & Steele, of Adelaide.

Are building four similar 6,000 ton vessels.

Walkers, of Maryboro', Queensland.

Are also building four 6,000 ton vessels.

This is an indication of the possibilities for future ship construction in Australia.

Under the present Australian tariff, vessels exceeding 500 tons D.W. are admitted duty free, but on January 1st, 1923, an alteration becomes operative, automatically levying a duty of 25 per cent. on British built vessels and 30 per cent. on vessels built elsewhere.

This means that an effort is being made to force the building in Australia of the steamers that will necessarily be required for Interstate traders as the population and business expand. This is certainly one direction where British builders might consider the advisability of joining forces and establishing an up-to-date yard in Australia in their joint interests.

Textiles.

In 1912 the imports of all descriptions under this heading totalled £19,495,762; in 1918 they totalled £21,824,729, an increase in value of approximately £2,500,000. This increase really means that there has been a big diminution in quantity, as during the period in question the cost of textiles, on an average, increased considerably over 100 per cent. upon 1912 values, so that in reality the actual imports of 1918 were not more than between 50 and 60 per cent. of the quantity imported in 1912. The balance was made up by local manufacturers. Had machinery been obtainable the difference would have been even greater, particularly in the production of woollen goods, and it is in this direction that considerable openings lie for British enterprise. At the present moment the Federal Government, in conjunction with the different States and wool growers generally, are considering a proposal to increase the Australian output of manufactured woollen goods. Taking the price of wool for 1918, the clip of Australia is valued at about £26,000,000. It is estimated that when converted into manufactured goods it would be worth at the same basic price £65,000,000, and the proposals now under discussion have the object of endeavouring to retain in Australia some portion of the difference in value between the raw material and manufactured goods. The proposals are that in each of the Australian States the wool growers should join with capitalists in finding the necessary money (£14,000,000), the Federal Government assisting in the finance on terms to be arranged. Whether the full proposal materialises or not, it is certain that considerable extensions in the manufacture of woollen goods in Australia are bound to take place immediately. Here, again, is an industry, where different British manufacturers could with advantage club together and prevent the overlapping which individual action is bound to cause. Those interested in this matter should bear in mind that the cost of producing wool in Australia has, up to the present time, been considerably less than in any other country in the world. It is estimated that while it costs 5 cents per lb. to produce wool in South America, it costs 9½ cents in the United States and 3 cents in Australia; these prices being, of course, for greasy

wool. Now, in addition to the actual difference in cost of production, there is a bigger shrinkage in the process of scouring in America than is the case with Australian wools, the American wools losing 60 per cent. and the Australian only 50 per cent. in weight. This means that clean wool in the United States on the above basis costs 23¾ cents per lb., against 6 cents of clean or washed Australian wool.

Cotton for mixing can be just as readily imported into Australia as into Great Britain, so there are no difficulties in the way of producing mixed goods as well as pure wool articles.

I have noticed in the English Press a number of articles emanating from Bradford, criticising and condemning the Australian proposals; but Bradford *must* recognise the fact that their dislike of the determination of Australia to increase her own manufactured woollens is not going to be affected by the natural desire of Bradford to retain the manufacturing for export overseas for their existing factories in this country. They *have* to realise that Australia has absolutely determined to increase manufacturing in her own country, and if the British manufacturers do not, as I have already suggested, come together and erect joint factories in the different centres, then the Australians or some other nationality will undoubtedly do so, and in the latter case the business would be lost to British interests.

Confectionery.

This is another case where Australia is determined to manufacture practically the whole of her requirements, and the following figures are illuminating:—

In 1913 Australia imported 4,760 tons of confectionery, valued at £572,000.

In 1917 Australia imported 2,760 tons of confectionery, valued at £418,000.

During the same periods Australia manufactured:—

In 1913 confectionery to the value of £1,657,045.

In 1917 confectionery to the value of £2,504,732.

At the end of 1917 an embargo against the importation of confectionery was imposed, so that for some time all imported confectionery was shut completely out. Three of your largest manufacturers, Messrs. Cadbury, Fry and Pascall, realising the position, have already acted on the lines suggested above, and these three firms have combined together and are now erecting a huge factory in Hobart to supply Australia with their well-known proprietary goods, which have previously had considerable sale throughout the length and breadth of Australia.

Wood Pulp and Paper.

So far wood pulp has not been manufactured in Australia, and indeed, very little paper making has been done. The normal importations into Australia are approximately as follows:—

	Tons.
Straw boards	6,007
Wrapping papers	12,746
Writing papers	7,260
Sundry paper	7,389
Apple wrapping paper	308
Blotting paper	410
Cardboard and paste paper ..	1,830
Leather boards, Manilla boards, cartridge papers, etc.	5,360
Printing papers	95,000
Total	136,370

Now at the present there are in Australia the following mills:—

One making printing, writing and blotting paper.

Three mills making wrapping and kraft paper.

Four making straw boards and box boards.

The value of the plants at present working amounts to about £400,000. The four mills making straw boards and box boards will probably shortly be in a position to supply the Commonwealth's requirements in these lines, but the other items are practically untouched and offer a big opportunity for British investment.

If the timbers and grasses of Australia are found suitable for the production of a high grade wood pulp, then in addition to the Australian demand there is the possibility of an export business. Tasmania, with her cheap water power and huge forests, offers an exceptional field for investigation.

Metallurgical Industries.

Owing to the complex character of so many of the Australian and Tasmanian ores, considerable developments have been made in Australia in metallurgical science, and there may not be so much room for expansion in this direction as in some of the industries already mentioned. At the same time, the possibilities of this phase of

Australian industry should not be overlooked, the mineral wealth of Australia being so great in the aggregate, and the potentialities still greater.

Prior to the War considerable quantities of Australian ores were exported to Germany for final treatment—they were largely the zinciferous ores from Broken Hill—but directly war broke out the Australian Government cancelled all contracts with Germany. Such ores are now being satisfactorily treated in Hobart by the electrolytic process rendered possible by the cheap hydro-electric power supplied by the Tasmanian Government. These works are now producing electrolytic zinc averaging 99.9 per cent. of purity, probably the highest grade zinc produced in the world to-day. The successful introduction of this industry means the later establishment of a considerable number of subsidiary industries, such as the production of Lithophone, Rolled Zinc, Metallic Aluminium, Ferro-Alloys, Zinc-Alloys, Caustic Soda, Bleaching Powder, etc.

Glucose.

This is another industry which war time necessities developed. Prior to the War, all glucose used in Australia was imported; in 1913 the quantity being 4,050 tons. To-day no glucose is imported, the whole being produced by manufactories that have sprung up since 1914.

Carbide and Electrodes.

In Tasmania a modern carbide factory was built capable of supplying the whole of Australia's requirements. The carbide is of a very high grade produced by electricity. The Company found on starting operations that the electrodes then obtainable were useless, and they had to build another factory to produce electrodes. This is also a going concern and capable of supplying such articles for any Australian industry requiring them.

Condensed and Preserved Milk.

This is a business that has only reached great importance during the last 10 years. Previously the milk canning industry led a very struggling existence, but during the last decade manufacturing difficulties appear to have been satisfactorily overcome, and to-day Australia is producing tinned milk by several different methods of a quality which is equal to that of other countries, where the industry is much older.

Australian milk is principally canned as sweetened condensed milk and dried milk: a considerable quantity of unsweetened milk is also put up, and it is anticipated that large increases in this method will take place during the next decade.

In addition to these three main lines, infants' and invalids' foods, lactose and powdered separated milk is also being turned out. Now, as Australia has almost unlimited capabilities for increasing her dairy herds, one can readily see the expansion in manufacturing milks that an increase in a primary industry like dairying will make practicable. This is certainly a field offering possibilities to British manufacturers which should not be overlooked.

Tin Plates.

As a subsidiary to the establishment of the iron and steel works this is an industry which is now being discussed. The normal Australian requirements for tin plates is approximately 40,000 tons per annum, and now that suitable steel is available, all the necessary raw material is locally produced, as tin is found in several parts of the Commonwealth. It only remains to put in the necessary plant for Australia to be self-supporting so far as this article is concerned. Those interested in the establishment of such a factory will have the English and American methods to choose from, but manufacture is almost certain to be on American lines. In England, skilled labour is still largely utilised, whereas in America tin plates are now produced automatically, absolutely dispensing with skilled labour. Whilst the plant is expensive it is more than compensated for by the advantage indicated.

Boots and Shoes.

For some time past Australia has been producing the bulk of the boots locally required. In 1917, whilst the value of local production was £4,617,000, importations only amounted to £449,000, a total consumption in Australia of approximately £5,000,000 per annum. Now that the cost of manufacturing in England, United States, etc., has increased so much, it is quite within the bounds of possibility that an export trade from Australia may be built up. Modern machinery and local hides would go a long way towards such a result.

Rubber Goods.

This is one of the lines which have benefited tremendously under war conditions.

In 1913 importations were £1,156,000.

In 1917 importations were practically the same amount.

On the other hand, local manufacturers increased from £782,000 in 1913 to £1,200,000 in 1917. The quantity of rough goods still imported, however, shows the possibilities of considerable expansion, whilst an export trade is being built up, rubber goods to the value of £160,000 being exported beyond the Commonwealth in 1917.

The Brewing Industry.

Another of the industries which profited largely from the War, as importations of English or foreign beers were practically cut right off, with the result that the Australian breweries had to make provision for supplying the full requirements of Australia. This they have done, and to-day the total value of the output of the brewing industry of Australia is something slightly over £4,000,000 sterling. In addition to catering for Australian requirements, an export trade is also being developed, and when it is realised that this industry is using hops grown in Australia and Tasmania—principally in Tasmania—local sugar and local glass for bottling, it will be seen how the necessities of this product are utilised to extend other manufactories as well as primary industries.

Cotton Industry.

This is one of the vexed questions of Australia, and one that is not yet solved. It has two branches, one of the production of raw cotton and the other the manufacture of raw cotton into material. As is known, the bulk of raw cotton is at present produced by America, and with the changes which seem to be taking place all over the world, it is not unreasonable to believe that an increase in quantity of cotton will be wanted as the coloured races utilise cotton materials more and more for clothing purposes. This will be better appreciated when one realises that of the population of 1,500,000,000 in the world, one-half are still only partially clothed, whilst 250,000,000 wear no clothing at all. Now, of the clothing worn, nine-tenths of the raw material is cotton; consequently the potential demand of the world is almost unlimited. Whether a cotton picking machine will ever be satisfactorily introduced to do away with the necessity for cheap labour for picking is still on the "Lap of the Gods," and until that comes there is very little likelihood of Australia, with her "White" policy, being a producer of raw cotton. On the other hand, as the bulk of her importations of cotton goods is from Great Britain, which has to import the raw material from America and elsewhere, and subsequently pay a big duty on landing the manufactured article in Australia, it is obvious that there will be a considerable increase in the production of manufactured cotton goods in the Commonwealth, which, of course, can now import raw cotton direct from America on practically the same terms as the British manufacturer, and in so doing cut out one freight, together with the duty on the manufactured article. This is certainly one of the businesses in which British manufacturers would be well seriously to act together and jointly establish factories in Australia for the production of cotton goods for this outlying portion of the British Empire.

Power.

Throughout Australia coal is practically the sole source of energy, but in Tasmania most of the power now used is supplied by the Government from their hydro-electric stations at the Great Lake. This State has a huge amount of latent energy in its high level lakes, the surveys completed up to the present day giving from these sources alone an estimated yield of over 200,000 horse-power. The present installation is producing about 25,000 horse-power, but new plant is now being installed to bring it up to 75,000 horse-power, and the cheap price charged by the Tasmanian Government, which is considerably lower than in any other part of Australia, has had the effect of considerable industrial developments in the Island.

In Victoria the Government are considering the possibility of producing electricity at the pit-head from the brown coal deposits and in the near future something is bound to materialise in this direction. There is no doubt, too, that if electrical energy was developed at the pit heads of Newcastle and Bulli in New South Wales, it would considerably assist the industrial development of that State. So far, in Australia producer gas has not been used to any great extent, and in no case for big installations. This is a source of energy which has been considerably developed in big units in the United States and is certainly

worth much greater consideration in Australia than has hitherto been given to it.

Oil fuel is another possibility, considerable shale deposits existing in New South Wales and Tasmania, but so far they have not been fully availed of. However, with the rapid conversion of coal-burning steamers into oil-burning vessels, it is a certainty that the shale fields mentioned will be utilised in the near future for the production of oil fuels. When this is accomplished it is also likely that the same fuel will be used for shore installations, and there is no doubt that the exploitation of the Australian shale fields offers one of the best possibilities for British investigation and capital. So far petroleum has not been discovered, although traces have been found. The Commonwealth Government have offered a reward of £50,000 for the discovery of petroleum oil in commercial quantities.

Viewing the power position in conjunction with the geographical position of the different States, I believe that the bulk of the industrial developments in Australia will take place in Tasmania, Victoria and New South Wales. Their central positions as distributing bases and the superior power position of the three States will, I believe, make them the industrial centres of Australia.

Future Developments.

Newcomers into Australia are frequently bothered as to the relationship of the Australian Commonwealth with the different independent States or Colonies which comprise the Commonwealth, and they frequently comment upon the fact that it takes seven Governments with six States Governors and one Governor-General to legislate for 5,000,000 people, and ask why cannot such a population content themselves with one Governor and one Parliament. The reason is that Australia is so large and climatic conditions so varied that one Government could not give satisfaction even now, and when in the course of time Australia contains between 50,000,000 and 100,000,000 people it would be a physical impossibility for one Government to give satisfaction to such a population over so vast a territory. Further, too, the different States seem to produce a different type of man, and the States themselves are all intensely proud of their individuality and strongly resent any attempt at further curtailment of their activities.

The Commonwealth was created by the different States in Australia, together with Tasmania, agreeing between themselves to transfer certain rights to one Federal authority. Beyond those distinctly specified the States refused to part with their sovereignty. Different attempts by some Federal legislators to increase Federal powers at the expense of the States have all failed, and, personally, I am of opinion that, if a fresh start could be made with the knowledge gained, a plebiscite would not now be in favour of Federation provided that a Customs Union was established and uniformity arranged with regard to Defence. However, the Australian Commonwealth is now *un fait accompli*, and we must accept the position. Prior to the War the cost of Labour in Australia was probably higher than in any other country, and with what has been termed fancy labour legislation, holidays and climatic conditions, there is no doubt the Australian workmen were living under the best working conditions in the world. An Arbitration Court was established to settle all trade disputes and prevent labour unrest, but, unfortunately, it has not had the desired result. There have been more strikes and greater unrest under the Arbitration Act than without it. First the employers were irritated beyond measure, and latterly the employees have lost faith in it, with the effect that the Court has practically broken down under its own weight. Attempts are being made to find some other panacea for the present mental indigestion that seems to be one of the aftermaths of the Great War.

During and since the War, however, Australian wages have not increased at anything like the same percentage as in Great Britain, America and other centres. Before the War, Australian labour costs practically meant that Australian manufacturers were confined to Australian demand, but now there is an approximate parity between the wages cost of Great Britain, America and Australia, there is a possibility of manufacturing for export in Australia that was non-existent before the War.

If employees will realise the benefit to themselves and their country in increased output and by so doing reduce our indebtedness and relieve taxation, it will immediately assist in the industrial developments of the country. Hitherto Union officials have claimed that reduced hours did not necessarily mean a reduction in

output, but Australian experience is to the contrary and every reduction in working hours has resulted in decreased output. The solution seems to me to get the Unions to adopt more largely the principle of piece-work in factories, fix a datum line of output (not for the country's aggregate output as discussed with the British coal miners) for each department in every factory and give employees a bonus on the excess of such datum line. This would give every individual employee a personal interest in the output of his department, and he would not be mulcted by the slackness of any of his fellow employees, either in his own or any other factory. Such an arrangement would help tremendously in further developing existing Australian industries and would undoubtedly help in creating new ones.

Other industries, such as sugar and tobacco, could also be helped by the introduction of labour from our allies, which would also help in strengthening the existing *entente.*

In reality the possibilities of industrial expansion are enormous, and if further proof were needed, it can be found in the amount of capital invested in new industries and extensions of old ones during the last four years. In that period the total cash subscribed in Australia for industrial expansions was £63,000,000, of which £25,000,000 was utilised for expansion of existing industries and £38,000,000 for new industries.

Whilst the question of manufacture in Australia is the primary object of this paper, another matter of equal importance is the development of Imperial trade between component parts of the Empire, and notwithstanding the desire of Australia to manufacture as much as possible of her own requirements, it is obvious that considerable quantities of goods have to be imported, and the policy of Australia is to give the production of British manufactures a very substantial preference. This is provided for by the tariff which gives a margin of from 5 per cent. to 10 per cent. in favour of British manufacturers against all other producers. This is practical evidence of the feelings of Colonials towards the Motherland. There is another way, however, in which the Colonies could also give preference to Great Britain. Where concessions are given by Colonial Governments to establish new works or industries, a stipulation might be imposed that all the plant required which could not be procured from local manufacturers should be of British manufacture.

On the British side of the question, however, and speaking generally, it seems to me that British manufacturers very often lose sight of the fact that Colonial expansions are taking place not only for the sake of the Colony itself, but more largely in the interests of the Empire, without which Empire their own British interests would soon diminish. Large British manufacturers are in a sense trustees of British trade, but more often than not such trusteeship is not considered a factor in the problems which present themselves to the Directors from time to time. Whilst referring to this matter I would also like to suggest that much greater use might be made of the Overseas Department of the British Board of Trade. Their organisation has done a considerable amount of work in endeavouring to bring British manufacturers and Colonial users together, but so far the support has been considerably greater from the Colonies than from the British manufacturers themselves. In this direction, too, I would also like to suggest that for export trade manufacturers should give more details in their advertisements and printed matter. Colonial buyers always want to know the price, the gross weight and shipping dimensions so as to estimate a laid down cost. Generally speaking, one or all of these three items are omitted from advertisements, leaflets, etc. The result is that the Colonial buyer has to write to England for the required information and lose three or four months. This often means in the case of seasonal products the loss of twelve months, and when the next season comes round something else crops up and the order is lost altogether.

Finance.

No paper on Australian industries and prospects is complete without some reference to the financial position of the Commonwealth and the individual States that comprise the Federation; and I will now give a table shewing the indebtedness of the Commonwealth and the States as at December 31st, 1913, the amounts added thereto during the war period and the total indebtedness as at June 30th, 1919. This is as follows:—

	Indebtedness as at Dec. 31st, 1913. £	Indebtedness added during war period. £	Indebtedness as at June 30th, 1919. £
Commonwealth ..	17,079,398	291,954,168	309,033,566
New South Wales ..	106,170,747	40,003,789	146,174,536
Victoria	62,776,724	19,255,205	82,031,929
Queensland	53,604,733	11,976,388	65,581,121
South Australia ..	30,147,883	12,503,323	42,650,206
Western Australia ..	30,276,436	13,360,640	43,637,076
Tasmania	11,495,963	3,785,313	15,281,281
	£311,551,884	£392,838,826	£704,389,715

The bulk of the increase during the period in question, inclusive of repatriation, is, of course, war expenditure. On the other hand, the individual wealth of the community increased considerably. This is evidenced by the fact that of the loans raised by Australia during the period, £213,470,000 was raised within the Commonwealth, whilst the deposits in banks and savings banks increased from £83,541,324 from 2,108,496 depositors as at June 30th, 1914, to £129,102,602 from 3,005,829 depositors at June 30th, 1919. Whilst, therefore, the total per capita indebtedness is very high, there is no uneasiness as to the ability of the community to carry the burden, pay interest thereon, and still keep taxation at about 50 per cent. less than that in Great Britain to-day.

At the present time the Exchange question is hampering trade between the United Kingdom and Australia, but this difficulty is considered to be purely temporary and could be largely overcome immediately if the Commonwealth Government permitted the export and sale of gold at the highest price obtainable now held in Australia by the trading banks and by the Commonwealth Government placing at the disposal of the Australian Banks in London considerable sums now lying here from the proceeds of Australian products sold by the Australian Government to Great Britain under pooled and controlled conditions, bearing in mind that such products would, under normal conditions, have been sold by traders and the proceeds returned to Australia through the usual trading banks instead of being locked up, as at present, under Federal control through the Commonwealth Bank. However, as soon as the new season's goods reach the English market, the position will automatically relieve itself, if not previously arranged, in some such manner as suggested.

Communication.

Trade expansions very often follow in proportion to the facilities provided for communication, transport, etc., and during the five years prior to the war, considerable improvements took place in the case of vessels trading between Great Britain and Australia. First the war, and now the high cost of production and fuel appear to have put a stop to these developments, and it looks as if increased facilities for communication between the two ends of the Empire will in the very near future have to depend more upon aviation and wireless. There is no doubt the developments in both these means of communication will facilitate trade intercourse, and here again is an opportunity for British enterprise to initiate and establish commercial aviation on a financial basis. There is little doubt but that the Governments of both Great Britain and Australia would be prepared to help and assist any such developments when they are assured that the technical and commercial management would be on sound lines.

Now, I am afraid that I must have wearied you with the length of my remarks. I know what wonderful work has been done in Australia during the past 30 years with a very small population, which to-day barely exceeds 5,000,000 people in territory somewhat larger than the United States.

I know the independence of Australians which is exhibited in the individual and his Government; I know his competence to tackle any proposition put before him which he thinks has a reasonable chance of success. I know his sporting instincts which induce him to "take things on" and trust to his luck and native wit to get round any difficulties or crises that may arise. I realise the immense wealth in Great Britain; I know the manufacturing knowledge and experience existing here; I know that the

same ideals animate the peoples of the two nations; that we have one Empire and one King, and my object is to try to induce British firms and British capital with the knowledge and experience they have behind them to associate themselves with the Australian interests in building up the industrial developments that will take place in Australia whether Britain comes in or not.

If the outcome of my paper is the establishment of one or perhaps two industries in Tasmania or Australia on the lines which I have suggested, I shall feel that my efforts have not been in vain.

In closing, I would like to thank the Overseas Department of the British Board of Trade for supplying me with some of the statistics given above, and the Royal Society of Arts for the privilege afforded me to place my views before you. I hope that I have succeeded in interesting you, and I shall be very pleased to endeavour to reply to any questions concerning the different matters I have referred to, if it is at all possible for me to do so.

DISCUSSION.

THE CHAIRMAN (the Right Hon. Sir William Ellison-Macartney), agreed with the author that Australia was at present wedded to a strong protective tariff, but whether it would remain in that position for all time he was not prepared to say. He did not admit the suggestion which had been made that there was anything of a revenue character in the tariff, which was intended by those who framed and supported it to be a distinctly protective one. It was desirable, he thought, in young States that the industrial development of natural products should be protected in their early years, and possibly the protection might be extended after they had secured a robust manhood. The peculiarity of the Australian tariff, however, was that it not only protected the development of industries based upon indigenous products, but it also incidentally protected manufactures to which that quality could not be attributed. In one case it was beneficial; in many others he could not help feeling it was injurious to a very large proportion of the population of Australia and to the greater part of the Continent. It was rather difficult to understand why a very intelligent portion of the earth's population should have accepted what he viewed as an unscientific tariff. He was not quite sure that the pastoral and agricultural sections of the population in Australia accepted the tariff with any strong belief in the benefits which it conferred upon them. Personally he thought that the hold which the tariff had over Australians, and the protection it offered to Australian interests, arose from the distribution of the population, over half of which was centred in sixteen large towns, nine of which were in three of the Eastern States. The result had been that, after the inception of federation and under the protection of the tariff, the two leading Eastern States had become the industrial and commercial masters of the rest of Australia. The development which had recently taken place in Tasmania, which would add an enormous amount of cheap power to a third Eastern State, would undoubtedly increase the control which that portion of Australia exercised over the rest of the Continent. It was difficult to say with confidence, whether in the future there would be any change of sentiment with regard to the tariff, and whether the other States which were subject to the Eastern States would throw off or attempt to modify the tariff so that it became scientific. He endorsed the author's statement with regard to unification, which summed up his views admirably with regard to the tariff. Australia contained such a vast area and the conditions were so different in one State from those obtaining in another, that it was impossible that one tariff framed upon one principle could give satisfaction, any more than one Governor-General or one Governor could give satisfaction to 50 or 100 million people. When the population of Australia reached 50 or 100 millions he thought the people to the West and the North of the Eastern States would begin to recognise more fully than they did at present how advantageous it would be that the tariff should be a scientific one, *i.e.*, a tariff which afforded all possible protection to the development of industries within Australia, that were based upon indigenous products, and which treated with milder force the manufactured products which were derived from materials that were not to be found in Australia, or products which could not be so efficiently manufactured there. The present tariff treated everything alike, except in one or two cases; it hurled a very heavy brick at any article coming from overseas, whether it was an article that could be produced in Australia or not. The absence of any movement in Australia to diminish the incidence of the tariff he attributed to the fact that more than half the population was situated in sixteen towns, and that it was extremely difficult in young countries to bring home the conception that the main and ultimate wealth of all nations consisted in the wealth of the land. That was the permanent asset of every country. The author had administered a very strong pill to the British manufacturer, but he had, with the astuteness of a polished family physician, coated it with a certain amount of jam. Whether the patient would find that the ultimate results of the jam were as effective as the main constituents of the pill he did not know; but he

said in effect to the British manufacturer, "Come and get over our garden wall and share with the patriotic Australian capitalist the advantages of manufacturing within this fortress which we have erected." That was all very well for the capitalist who could transfer his capital by wire to one of the three Eastern States, but it was not so satisfactory to the British artisan, whose interests were bound up in manufacture with the capitalist. He echoed the author's hope that the margin of prospective industrial development in Australia would fall into the hands of British capitalists, but the question was what that margin would be. Personally he thought there was an economic condition which might place a limit upon it, namely, the extent of the population within the area protected by the Australian tariff. The author had shown that the development during the last few years of the internal industries of Australia might be put not lower than 50 per cent., but in looking at the increase of population it did not come to anything like that figure; so that, sooner or later, the possibility of industrial development must reach a limit imposed upon it by the population. Until that limit was reached there was an opportunity for the British capitalist to come in and take advantage of the situation. There was no reason why Australia should not take advantage of the great store of natural resources it possessed and develop them in any way it desired, in accordance with the natural laws which must govern all developement.

The HON. J. G. JENKINS said he did not altogether agree with the Chairman's remarks on the tariff question, because 33 years ago he was a member of a Committee which practically arranged the tariff that was enforced in South Australia. Some of the residents very strongly opposed it at the time, whether for protection or revenue purposes, and he remembered a large merchant who was interested in the boot trade arguing that the price of boots would be raised because the possibility of importing cheap goods would be prevented. Years afterwards that man was the proprietor of one of the largest boot factories in Australia, where boots were produced at a great deal cheaper price than was the case when he used to import them. Personally, he (Mr. Jenkins) was entirely in agreement with the protective tariff to protect those industries in a State where goods could be manufactured to advantage. There were certain other things that were imported that it was impossible for a new State to manufacture with advantage because they had not the necessary raw material. Australia, however, possessed wool, leather and many other materials, and it was to the advantage of the country to encourage the manufacture of articles from those products in the country itself. It was essential, as far as possible, that the component parts of the Empire should trade with each other, and he believed that, in time to come, a united effort would be made to assimilate the tariff between the different parts of the Empire, advantage being taken of the raw products in one part for manufacture in another part, where it was advantageous to manufacture them elsewhere, a concession in regard to tariffs being given against the other parts of the world. The Chairman had said that Australia threw a brick at everybody, so far as the tariff was concerned. As a matter of fact, Australia and the other dominions only threw half a brick at Great Britain and the other portions of the Empire, and that had resulted in over four million pounds benefit per annum being given to British manufactures. It was impossible with the present wages in Australia, to compete with other countries in the growth of cotton; but in the future there should be no necessity to go to the United States for that article, because just as good cotton could be obtained from the British Colonies—in Africa and the Pacific Islands. If encouragement were given to British cotton growers, something might be done in the way of instituting cotton manufactories in Australia as well. There could be no question that Australia was one of the most favoured countries in the world so far as iron ore was concerned. The Broken Hill works at Newcastle produced about 200,000 tons last year, and they would be able, within the next 12 or 18 months, to add another 100,000 tons to the total; whereas before the commencement of that industry, Australia imported about 600,000 tons of steel every year. He did not altogether agree with the establishment of the ship-building industry in Australia at present, because ship-building yards had been established in this country at which vessels could be made cheaper than in any part of the world, and the experiment of trying to compete with them in the matter of cost simply meant taking money out of the taxpayers' pockets in Australia. America was having the same experience. In cases where established works existed at which articles could be made cheaper than in one's own country, it was better to pay attention to other manufacturers instead of trying to compete in those particular lines. In reply to a remark made by the Chairman, he desired to point out that if works were erected in Australia, further work would be available for the artisans of this country who would emigrate there.

The HON. EDWARD LUCAS (Agent-General for South Australia) said he would very much like to know what a scientific tariff was, as mentioned by the Chairman. A scientific tariff did not exist in Australia, and it was never intended to be scientific. It was formed for the double purpose of creating a revenue, and to protect the industries that existed and enable others to be established.

The Chairman had referred to the tremendous disparity between the population of the towns and of the land in Australia; but he had never heard a speaker remark that 78 per cent. of the total population of England consisted of town dwellers, the remaining 22 per cent. being on the land. It would be well if some of the speakers in Great Britain made a mental note of that fact. One of the greatest problems which confronted all nations was how to keep people on the land and prevent them flocking into the towns and cities. The tariff of this country was not very scientific, because it allowed the wheat of the world to come in free and would not protect the farmer, but it protected the motor manufacturer, who made luxuries that a great many people could do without, by imposing a 33⅓ per cent. tariff. He desired also to controvert the Chairman's statement that the other States of Australia were dominated by the two big Eastern States. In the House of Representatives, the States were represented on the basis of population, but in the Senate, every State had an equal representation. They were not dominated in the Senate nor in any other respect. The States of Australia were self-governing sovereign entities which were absolutely autonomous, and they were altogether in a different position from the Provinces of the Dominion of Canada. They were vested with the power of life and death and taxation, and no one State could dominate another. The author had indicated that New South Wales and Victoria would probably be the principal States that would develop manufactures in future, because they would benefit from the harnessing of the River Murray, but South Australia had more water than any other State, and when it was harnessed he had no doubt that it would hold its own as a manufacturing State.

Mr. E. B. Tredwen said he was born and brought up a Free Trader, but after going to Australia and watching the conditions there, he eventually became a Protectionist and an advocate of the adoption not of a scientific tariff but a practical tariff, in this country. The natural industries of a country could not be developed unless they received a little encouragement at the start. Speaking as a merchant, and as Chairman of the Australasian Merchants' Association, he wished to say that his object was to do trade with Australia, but, whereas at the present time there was about one-fifth of a cargo for every vessel that loaded for Australia, in the no very distant future there would not be one-tenth of a cargo for every ship that went to Australia to bring back its products. That was not altogether an encouraging thing to the merchants who wished to ship goods to Australia, because exports to Australia would dwindle until Australia herself supplied practically the whole of her requirements and began to export to the world. He thought Tasmania was destined to be the greatest manufacturing State in Australia, owing to its magnificent water power. The Exchange question affected every merchant at present very severely, because orders were received from Australia to ship goods which that country badly needed, and after buying and paying for them the merchants could not get paid owing to the difficulties connected with exchange created by the trading activities of the Commonwealth Government. It had monopolised the trade in gold and in addition had entered into an extensive ship-building programme; a considerable amount of money in the hands of the Commonwealth Bank was being held to pay the instalments as they fell due on those ships. All experience showed that Government ship-owning was disastrous, expensive, and inefficient, and involved a very much heavier expense than would be the case if the trade were left in the hands of those who understood it. The British Government had to build certain ships as an emergency measure during the War, but it did a statesmanlike thing when the War was over by selling them. It got a good price for them, and came out of the transaction with credit to itself and benefit to the community. If the Commonwealth Government had been statesmanlike instead of following political expediency, it would have sold its ships in the same way, and 20 million additional capital would have been available to finance drafts, most of which at the present time could not be financed. Government trading was the real cause of the financial trouble at the present time. Governments should do what they could to foster trade and not interfere in its actual activities.

Mr. G. T. Milne (Department of Overseas Trade), who was H.M. Trade Commissioner in Australia in the period 1913-18, said that if British manufacturers found that their export trade was declining owing to the development of local industries and the stress of foreign competition, it was necessary for them to consider the best remedy that was available. If they came to the conclusion that the best remedy was to work within the Australian tariff, they should go to Australia and see if anything practical could not be arranged. Some manufacturers had done so, with the result that a certain number of industries had been started. There could be no doubt that the movement had come to stay because the old idea that Australia and the Colonies could be made use of solely for the export of finished products from this country and the import of food stuffs and raw materials from them, had passed away. In future the Dominions intended to develop their natural resources themselves as far as possible by manufacturing locally. With reference to the suggestion that British export trade to Australia

would diminish, in his opinion there would be a diminished trade in some branches and an increase in others. For instance, in the textile industries, to which reference had been made, for some years to come Australia must import machinery, because it was hardly likely that complex textile machinery could immediately be manufactured in that country. It would also be necessary for certain high-class goods in every industry to be imported. If the export trade to Australia entirely stopped, how would the adjustment of the trade balance between the two countries take place? It was quite inconceivable that this country would pay Australia in gold for wheat, meat and other products. Even a highly developed country like the United States in normal times imported large quantities of goods from England, and Australia was not nearly so highly developed as the United States. Mr. Ashbolt had stated that people from overseas made more use of the Overseas Trade Department than the manufacturers of this country. The Department had felt the stress of war and it was now larger and better organised than it was years ago. The very largest firms, particularly in the engineering trade, now went to it for assistance and advice, and the manufacturers and exporters of the country were beginning to see more and more that the Department was an entirely unbiassed source of information. In the name of the Department, he thanked Mr. Ashbolt for his most interesting paper.

MR. W. J. MIRRLEES, in proposing a hearty vote of thanks to the author for his valuable paper, said the problems which had been dealt with in the paper were exactly those experienced in South Africa, except that South Africa was distinctly farther back in progress than Australia. They felt there the necessity of utilising products on the spot through the skill, knowledge and capital of British manufacturers. Manufactures had been started in South Africa with a certain amount of money, a large amount of enthusiasm and very little practical knowledge. Some of them had survived. He had also seen other manufactures which were a success from the first started full-fledged with the knowledge and experience of the British manufacturers, not only British capital but the higher branches of British labour being utilised. As these industries advanced they provided an outlet for the young men of the Colony. That had the effect of satisfying a want in those countries. In his opinion the greatest asset of a country was the people and not the land. It was necessary to have a strong, educated and satisfied people, and those qualities would never be obtained if the land was all that was offered to them. This was the strongest argument for the establishment of industries in the Colonies, and in his opinion these should be established by the manufacturers of this country, who alone had the knowledge to make them a success within a reasonable time. He also represented the British Empire Producers' Organisation, which existed with the object of welding together the producers alike in this country, Australia, South Africa, Canada and elsewhere, and the Organisation was admirably suited for the purpose of giving the information for carrying out the objects of the paper.

MR. E. T. SCAMMELL seconded the motion, which was carried unanimously.

MR. ASHBOLT, in reply, said the establishment of new industries in Australia would not only enable capitalists to transfer their money there, but would provide work for the surplus population of this country, and for whom the Government were trying to find occupation overseas. Personally he did not agree with the idea of building ships in Australia and some of the other things that were done there, but Australia had so decided and he mentioned the fact for the purpose of bringing out the point that duties of 25 and 35 per cent. would be imposed upon ships made elsewhere. Some of the speakers had given evidence of the individuality which he he claimed for all the States. Each state was jealous of its sovereign rights, and each produced an individuality which it wished to retain. He desired, in conclusion, to express his appreciation to the Chairman for his study of the paper and the views he had placed before the meeting; and he had also been requested, on behalf of the Council, to express to Sir William their thanks for his kindness and courtesy in taking the chair.

The meeting then terminated.

OBITUARY.

NEVILLE PRIESTLEY, INDIAN P.W.D., RTD.—Mr. Neville George de Bretton Priestley died on December 13th, aged 59. His long and distinguished connection with railway management in India—he spent thirty-three years in that country, and since his retirement, in 1911, had been Managing Director of the South Indian Railway Company—began with his appointment, in 1879, to the Traffic Department of the State Railways. For twelve years his services were lent to the Bombay, Baroda and Central India Railway Company. Later he became Traffic Manager of the Southern Mahratta line, and when the then Viceroy, Lord Curzon, commissioned a great railway expert, the late Mr. Thomas Robertson, to visit India for the purpose of investigating the working of railways there, Mr. Priestley was chosen to assist him, and actually, it is understood, drafted the Commissioner's report. This, doubtless, led to Mr. Priestley being entrusted with a mission to the United States to study the American railway system. One outcome of Mr. Robertson's inquiry was the

establishment of an Indian Railway Board, and Mr. Priestley was its first Secretary. During the last five years of his Indian service he filled the post of General Manager of the South Indian Railway. Soon after he returned to England, on his retirement, he joined the Royal Society of Arts, and in 1912 read a most valuable paper before the Indian Section on "Indian Railways," particularly in relation to finance and the difficulties that have prevented more rapid progress in construction.

OIL SHALE DEPOSITS IN BULGARIA.

The existence in Bulgaria of large deposits of oil shale or bituminous schist has been known for some years. Recently, owing largely to the increased demand and higher prices for oil and its related products, there has been renewed interest in the subject, and already three concessions have been granted for the exploitation of these deposits. While no actual development work has yet been undertaken, it seems probable, writes the U.S. Consul at Sofia, that such work will be begun in the near future.

The most important shale deposits in Bulgaria are in the following localities :—

1. *Near Breznik*.—These deposits are found about six miles north of the town of Breznik. Here occur sandy, clayish shales and lime beds. Among the sandy deposits is included a bed about 150 feet thick, formed of deposits of oil shale. According to the oil percentage in this bed the shale may be divided into three grades, one of which contains from 12 to 13 per cent. of crude oil. The thickness of this layer is about 20 feet. The total amount of these shales is enormous, the estimate being 30,000,000 tons for the surface shale only. The deposits are about 15 miles from the railway line.

2. *Near Radomir*.—The deposits here are found about five to seven miles west of the railway line Sofia-Batanovtzi-Radomir. These are graphite deposits and extend for a distance of about 12 miles. The thickness of this shale deposit has not been determined, but it appears to be even larger than the one near Breznik.

3. *Near Popovtzi*.—These deposits are found along the railway line Stara-Zagora-Tirnovo, slightly more than one mile south of the station of Popovtzi. The soil here is composed of earthy layers in which a deposit of bituminous shales is found. These appear to be from nine to ninety feet in thickness and to extend for a distance of about five miles.

4. *Near Kazanlik*.—These deposits are found west of the town of Kazanlik, near the village of Saltikovo. They are similar to those found at Popovtzi. The thickness, as far as determined up to the present, is about 30 feet.

5. *Near Sirbinovo*.—These deposits are found about nine miles south of the town of Gorna Djoumaya, near the village of Sirbinovo. The soil here is composed of earthy layers, in which are found deposits of bituminous shales together with layers of lignite. According to the investigations already made, the layers of shale appear to be about 80 feet thick and the layers of lignite from six to eight feet thick. The shales which have been studied from this region were found at distances of from one to two miles of each other. The quantity of these deposits appears almost unlimited. They are found at a distance of from two to three miles from the narrow-gauge railway line Radomir-Dupnitza-Roupel.

In addition to the geological and regional study of the shale deposits mentioned, a number of analytical studies have also been made. Of these the most thorough study has been made of the shales found in the vicinity of Breznik. Five tons of these shales were sent to Scotland for analysis. This test showed 13 per cent. of crude oil. Analyses of the same shales in Berlin and Sofia in 1917 and 1918 showed from 10 per cent. to 13 per cent. of crude oil. On comparison of these shales with Scottish shales the latter showed a higher percentage of kerosene, petrol, and sulphate of ammonium, while the Breznik shales showed a higher percentage of benzine, lubricating oil, and paraffin wax.

The shales found near Radomir were studied in 1916 in the Geological Institute in Berlin by Prof. Baischlag. These shales came from the very surface and showed eight per cent. of crude oil.

Tests have been made of the shales found near Popovtzi by the mining section of the Department of Commerce, Industry, and Labour. These show seven to 13 per cent. crude oil. The best results of all have been obtained from tests of the shales found near the village of Sirbinovo. An analysis of these made in the mining section at Sofia shows 21 per cent. of crude oil.

It would appear from the above, adds the U.S. Consul, that the shales found in Bulgaria are not inferior in their oil content to those found and exploited in Scotland, where at their best only 12 per cent. of crude oil is yielded. It is said that during the war the industry of distilling oil from oil shale reached such a state of perfection in Germany that it was found profitable to distil shales yielding only five per cent. of crude oil.

The three concessions already granted for the production of mineral oil from oil shale are in the region of Sofia, Kustendil, and Vratza; in the region of Stara-Zagora ; and in the region of Gorna Djoumaya and Philippopolis.

At a time when the use of oil-consuming vessels is increasing throughout the world and the demand for oil bids fair to exceed the supply, each nation will make every endeavour to discover and exploit new oil fields. While Bulgaria has no oil wells, it may be that the oil shale deposits found in the country will prove of considerable importance in the future development of the mineral oil industry.

GENERAL NOTES.

AGRICULTURAL POSSIBILITIES IN NEW GUINEA.—The Bismark Archipelago, including that portion of New Guinea formerly controlled by the Germans and known as Kaiser Wilhelm's land, is favourably situated for the development of tropical agriculture. At present, according to the American Trade Commissioner in Melbourne, most of the cultivation is on low country, and, as is natural where communication is largely by water, is mostly coastal. There are, however, highlands in the mountain ranges running up to 3,000 or 4,000 feet above sea level that are eminently suitable for agriculture and easily accessible, and there are already several hundred miles of good roads connecting up the plantations and traversing such areas. Native labour is obtainable in reasonable quantities at a cost equivalent to 24 cents per day, exclusive of recruiting charges. The main agricultural products at present are coconuts, cocoa, rubber, coffee, arrowroot, *kapok*, tobacco, and maize. Of these, the larger proportion are coconuts, there being about 7,000,000 palms under cultivation in the possessions. The copra returns for 1918 were about 21,200 tons, and for 1919 they are estimated at 27,000 tons. Cocoa is of high quality and commands a good price. Other staples for which the climate and soil are suitable are fibres, including manila and sisal hemps, sugar, tea, cinchona, rice, spices, oils, fodders, and the like. The government maintains a department of agriculture, plantations, experiment stations, and demonstration plots.

HENEQUEN CULTURE IN CUBA.—Three companies, two Cuban, the other Cuban and Mexican, are now engaged in the henequen industry which has sprung up in the Cardenas district of Cuba within recent years. Lying between the cities of Cardenas and Matanzas are several thousand acres of land, hitherto considered unsuitable for agricultural purposes, but now planted to henequen. The acreage devoted to this plant is constantly increasing, while a large, modern, decorticating plant for extracting the fibre has been recently completed at Cardenas and is working at full capacity. The cordage manufactured at the Matanzas plant is of the highest quality and finds a ready market in the face of competition with the products of the Philippine Islands and Yucatan. The industry is now on a stable footing and promises to become an important factor in the agricultural and industrial life of the Province.

SHEEP RAISING IN TAIWAN.—With a view to affording a local supply of wool for Japan, the Imperial Government began in 1918 to breed sheep. As the climate of Taiwan was thought more nearly like that of other sheep-raising districts, it was hoped to develop a breed suitable for that climate by cross breeding, and to that end 169 sheep were imported from Northern Japan, Tsinanfu, China, and Mongolia, and others will soon be brought from Australia. As soon as a satisfactory breed is established, a few head each of healthy stock will be given to the farmers, who will be instructed in sheep raising. It is thought that in addition to the profits from the wool the mutton will find a ready market and add to their income, and also that tanning leather will become an established industry.

COHUNE NUTS IN MEXICO.—Cohune nuts, which are referred to in Mexico as Coquitos de Aceite (little oil coconuts) contain a very high percentage of oil. As a result of various experiments, writes the U.S. Commercial Attaché at Mexico City, this percentage is fixed at between 60 and 65, but with present methods of extraction, from 50 to 55 per cent. is the actual yield. The oil is used for the manufacture of soap, candles, and, in certain States of the Republic, for lighting purposes. In the southern district of Purificacion, State of Jalisco, about 200,000 kilos of cohune nuts, valued at \$0.20 (10d.) per kilo, are produced without cultivation in a zone 20 kilometres square. The resulting oil is estimated at 116,667 kilos, and it is thought that with improved methods of extraction a larger percentage of oil might be secured. The district of Coalcoman, State of Michoacan, contains 900,000 cohune nut trees, although the harvesting of this crop is not carried on systematically, and, therefore, only about 8,000 kilos of nuts are obtained. It is reported that 129,600 kilos of cohune nuts are produced in the district of Tabares, State of Guerrero.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

JANUARY 12.—CHARLES S. MYERS, M.D., Sc.D., F.R.S., Director of the Psychological Laboratory, and Lecturer in Experimental Psychology, University of Cambridge, "Industrial Fatigue." (Aldred Lecture.) W. L. HICHENS (Chairman, Messrs. Cammell, Laird and Co., Ltd.) in the Chair.

JANUARY 19.—F. M. LAWSON, Assoc M.Inst.C.E., "The Future of Industrial Management." SIR ROBERT A. HADFIELD, Bt., D.Sc., D.Met., F.R.S., in the Chair.

JANUARY 26, at 4.30 p.m.—A. ABBOTT (Department of Scientific and Industrial Research), "The Origin and Development of the Research Associations Established by the Department." W. GREENWOOD, M.P., Vice-President, British Cotton Industry Research Association, in the Chair.

FEBRUARY 2.—A. F. BAILIE, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World." PROFESSOR SIR JOHN CADMAN, K.C.M.G., D.Sc., in the Chair.

FEBRUARY 9.—WILLIAM ROTHENSTEIN, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England."

FEBRUARY 16.—WILLIAM CRAMP, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice."

FEBRUARY 23, at 4.30 p.m.—SIR DANIEL HALL, K.C.B., F.R.S., Permanent Secretary, Board of Agriculture, "The Present Position of Research in Agriculture." (Trueman Wood Lecture.) Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the Chair.

INDIAN SECTION.

Fridays at 4.30 p.m.

JANUARY 21.—R. S. TROUP, M.A., C.I.E., Indian Forest Service, Professor of Forestry at the University of Oxford, "Indian Timbers." SIR CLAUDE H. A. HILL, K.C.S.I., C.I.E., in the Chair

FEBRUARY 18.—Paper to be announced later.

APRIL 22.—Paper to be announced later.

MAY 27.—WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

COLONIAL SECTION.

At 4.30 or 5 p.m.

MONDAY, JANUARY 3, at 5 p.m.—FRED. C. CORNELL, O.B.E., "The Alluvial Diamondiferous Deposits of South and South-West Africa." MAJOR SIR HUMPHREY LEGGETT, R.E., D.S.O., in the Chair.

TUESDAY, FEBRUARY 1, at 4.30 p.m.—G. C. CREELMAN, LL.D., B.S.A., Agent-General for Ontario, formerly Commissioner of Agriculture and President, Ontario Agricultural College, "Modern Agriculture."

INDIAN AND COLONIAL SECTIONS.
(Joint Meetings.)

At 4.30 p.m.

FRIDAY, MARCH 4.—WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

TUESDAY, MAY 3.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

HOWARD LECTURES.

ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E., "Aero Engines." Three Lectures. January 17, 24, 31.

Syllabus.

LECTURE I.—Early Attempts to Produce Motive Power for Flight—External and Internal Combustion Methods—Possible Fuels—Materials of Construction—Steam, Reciprocating and Turbine Engines and Internal Combustion Engines—Development as regards Thermal Efficiency, Power and Weight—Thermodynamic Cycles in Internal Combustion Engines—First successful Engines in Flight—Aero Engines in 1910—Development before 1914—Relative Importance of Weight and Fuel Economy.

LECTURE II.—British and German Aero Engines at the beginning of the War—Development of the six main types during the War—Comparison of British and German Practice—Special Experimental Types—Limiting Conditions in Different Types—Supercharging—Examples of Different Types.

LECTURE III.—Engines in use after the War—Comparative Tables of Piston Speeds, Mean Pressures, etc. — Conditions Governing and Limiting Further Progress—Variations of Thermodynamic Cycles—Regeneration—Possible Progress as regards Materials—Future Development of Aeroplane and Airship Engines.

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures, February 14, 21 and 28.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and the Industrial Applications." Three Lectures. March 7, 14 and 21.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.C., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

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FRIDAY, DECEMBER 31, 1920.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 3rd, at 5 p.m. (Colonial Section), FRED. C. CORNELL, O.B.E., "The Alluvial Diamondiferous Deposits of South and South-West Africa." MAJOR SIR HUMPHREY LEGGETT, R.E., D.S.O., in the Chair.

THURSDAY, JANUARY 6th, at 3 p.m. (Juvenile Lecture) SIR FREDERICK BRIDGE, C.V.O., M.A., MUS. DOC., Emeritus Organist, Westminster Abbey, "The Cries of London which Children heard in Shakespeare's Time." (The lecture will be musically illustrated. Special tickets are required for this lecture, and no person can be admitted without one. A few tickets are still left, and these will be issued to Fellows who apply for them at once.)

LIST OF FELLOWS

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

CASES FOR JOURNALS.

At the request of several Fellows of the Society, cases have been made for keeping the current numbers of the *Journal*. They are in red buckram, and will hold the issues for a complete year. They may be obtained post free, for 7*s*. 6*d*. each, on application to the Secretary.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FOURTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 8TH, 1920.

THE RIGHT HON. LORD CARNOCK, G.C.B., G.C.M.G., G.C.V.O., K.C.I.E. (Ambassador to Russia 1906-1910), in the Chair.

THE CHAIRMAN, in introducing the author of the paper, said that no one was better qualified than Mr. Brayley Hodgetts to deal with questions relating to Russia, whether from a literary, historical or economic point of view. Mr. Hodgetts had lived in Russia for a considerable time, he had a thorough knowledge of the language of that country, and he was well versed in its literature. He was the author of several works dealing with Russia—notably one on Russian Court Life in the Nineteenth Century, and another a life of Catherine the Great. He had also written a novel of Russian life, and a work descriptive of the condition of the Russian peasantry.

The following paper was then read :—

A RETROSPECT OF THE PERSONAL INFLUENCE OF BRITONS IN RUSSIA.

BY E A. BRAYLEY HODGETTS, ASSOC INST. C.E.,

Chairman, Russian Section, London Chamber of Commerce.

To trace the early beginnings of British influence in Russia would take time and labour; so far we have but fragmentary indications. We know that in pre-Norman times the British opened up commerce with Russia by means of the Osterlings, the merchants of Gothland. These Baltic traders had their headquarters at Wisbey. Evidences of trade with Britain are constantly met, especially round the Neva

and the upper reaches of the Volga, and as far east as Orenburg, in the shape of English coins of a date prior to the Norman Conquest, and fragments of Anglo-Saxon pottery. Alfred the Great is believed to have inaugurated the first trading with the inhabitants of the shores of the White Sea, by sending his ships under Norwegian navigators who supplied him with material for the earliest description of these regions in the English tongue. Alfred was the first Englishman of note to recognise the possibilities of trade with Northern Russia. There appears to be little doubt that international relations between England and Russia were established long before the Conquest, but were broken off and forgotten in consequence of Tartar invasions and political upheavals. The influence of those distressing events on the progress of the country, and the service Russia rendered Europe in acting as a dam against the inflowing wave of Mongolian invasion, these are matters which cannot be adequately treated in a parenthesis. Naturally, the progress of the country was arrested.

The cities of Novgorod and Pskov were virtually members of the Hanseatic League, with which they had traded since the 13th Century. Ivan the Terrible, however, the consolidator of Russia, had little inclination to foster such republics in his empire, and he regarded the Hanseatic League as a dangerous German monopolistic institution. He fully recognised, on the other hand, the importance of cultivating friendly relations with England, which was, at that time, successfully competing with the League.

We will not dwell upon his somewhat ludicrous attempts to contract a matrimonial alliance in England or on the embassy he sent to this country. These attempts did not seem so ludicrous to him as they did to us, seeing that as far back as in the eleventh century one of the daughters of Yaroslav I., Elizabeth, married Harald Hardrada, the Norwegian King who fell in battle against our Saxon Harold. Another daughter married Henry I. of France. Moreover, according to Icelandic Sagas, Gyda, Harold of England's daughter by Edith of the Swan's Neck, after spending some time in Denmark, was married to a Russian Prince, whom the late W. R. S. Ralston described as seeming to have been Vladimir Monomach.

It is not surprising, therefore, that when Ivan heard of the arrival at Archangel of English merchants, he welcomed them, invited them to Moscow and treated them with every courtesy and distinction.

These merchants were the fore-runners of the Franco-British entente, for it was Cabot, the French explorer, who had got them together and formed the Mystery Company and Fellowship of Merchant Adventurers for the Discovery of Unknown Lands; among the other founders were Robert Thorne and Lord Willoughby de Broke. In 1552, three vessels were fitted out and despatched to find a passage round Norway to China, then called Cathay. These vessels were the Bon Esperanza, 120 tons, the Edward Bonaventura, 160 tons, and the Bon Confidentia, 90 tons. They sailed under the command of Sir Hugh Willoughby and Richard Chancellor. The Edward Bonaventura cast anchor at Nenocksa in the White Sea, in the mouth of the Dvina, on August 24th, 1553, Master Stephen Burrough, Mate John Buckland. Sir Hugh Willoughby was wrecked and lost his life. In 1853 the Russian Academy of Sciences proposed the erection of a monument to him on a site near the scene of the disaster.

The Edward Bonaventura had on board, besides the above master and mate, the Rev. John Stafford, Dr. Thomas Walter and about 47 others, among whom were George Burton, Arthur Edwards, John Hasse (who had written about Russia), Arthur Pet, William Burrough, Richard Johnson, John Sedgwicke, Edward Passy etc.

It is interesting to record these names, for these were the pioneers of British influence in Russia, and from these small beginnings there developed that great Corporation, the Russia Company, a chartered company, like the Honourable East India Company, and started in much the same way, as a purely trading organization, which later, under the wise fostering care of Russia's rulers introduced industry, formed what was called the English Factory, and promoted a number of excellent enterprises. More especially, and for the special benefit of the young men it employed, some of whom were tempted to fall away from grace, and to dissipate locally the moneys of their employers, they founded English Churches, and maintained English clergymen, who thus became centres of culture and British influence. This is still one of the functions of the Russia Company,

and the papers have told us how nobly Mr. North, for instance, has to-day, under the most difficult circumstances, maintained the best traditions of the Church of England.

The footsteps of these ancient pioneers have been more recently followed, towards the close of the last century, by Captain Wiggins, who went somewhat further afield and discovered a northern sea route from the Thames through the Arctic and the Obi and Yenisei rivers to the very heart of the fertile fields of Siberia.

Captain Wiggins was accompanied in 1877 by Henry Seebohm, the ornithologist, whose "Siberia in Europe," 1880, and "Siberia in Asia," 1882, placed the ornithology of that region on a scientific basis.

What Seebohm did for Siberian ornithology, Sir Roderick Impey Murchison did for her geology. Born in 1792, this remarkable man commenced his career in the army, went through the Peninsula War, and did not devote himself to scientific pursuits until piping times of peace set in. After publishing his famous work on the Silurian System, he proceeded, in 1839, accompanied by de Verneuil, to Russia. Greatly aided by the officials and savants of that country, Murchison crossed the Northern part of Russia to the shore of the White Sea, and thence up the Dvina to Nijni Novgorod, Moscow, and back to St. Petersburg. In the following summer the two travellers returned to Moscow, and after examining the carboniferous rocks in central Russia, struck off for the Ural Mountains, followed them southward to Orsk, thence westward to the Sea of Azov and so back to Moscow. After a third visit to St. Petersburg by way of Scandinavia and Finland, the important work on "The Geology of Russia and the Ural Mountains," by Murchison, von Keyserling and de Verneuil, was published in 1845. That this work, which partook of the nature of a geological survey of Russia, was a great achievement, and conferred a great benefit on that Empire, is universally acknowledged. Indeed, the Emperor Nicholas I. fully recognised Murchison's great services, and conferred on him the highest decorations in his gift, besides bestowing on him numerous valuable presents. Sir Roderick Murchison was, fortunately for himself, one of those rare phenomena, a wealthy man of science, and was not in need of pecuniary rewards. In his house in Belgrave Square, he dispensed a princely hospitality, and though his detractors have accused him of having too little imagination, that defect, in a geologist, was not an unmixed evil. At any rate, it is universally recognised that he possessed a sound Scottish intellect, and if he made mistakes in Cornwall and Devon, he at least laid the foundation of Russian geology. He died in 1871. Freshfield and Baddeley have similarily described the Caucasus.

But to return to more remote periods. Numerous Scottish soldiers of fortune served Russia in the 17th Century. All who have read Sir Walter Scott's "Old Mortality" will remember the grim figure of General Dalzel, who was supposed to have practised nameless cruelties during his sojourn in the fabulous land of Muscovy. The Russian poet Lermontoff claimed to be descended from the legendary seer and poet, Thomas Learmont, of Erceldoune, who flourished in Scotland during the thirteenth Century from about 1220 to 1297.

More interesting is the fact that Peter the Great's mother, Natalia Naryshkin, was the ward of Artemon Matveyieff, whose wife was a Hamilton, a member of a Scottish family settled in Moscow. This girl's father, Cyril Naryshkin, had a brother, Theodore, who had also married a Hamilton, the niece of Matveyieff's wife, under whose charge Natalya Naryshkin received her education at Moscow. That the Hamiltons introduced Western customs into the Matveyieff household, appears from the fact that Matveyieff himself had served in foreign regiments, was known to have a leaning towards Western Europe, and had adopted different manners from those of the Muscovite aristocracy. His womenkind dressed in the Western fashion, and even appeared at table when visitors were entertained. Thus it is not very far fetched to assume that Peter the Great himself received his first impetus towards the manners and customs of the West from his mother, who had a Scottish aunt and had been brought up by a Scottish lady.

Still more interesting is the fact recorded by Eugene Schuyler that "it was the Englishman, John Merrick, first merchant and subsequently ambassador, who was one of the earliest to teach the Russians that it was better for them to manufacture for themselves than to export the raw materials."

It is on May 10th, 1690, that we first

hear of Peter the Great dining with General Gordon, who is thus described by Schuyler: "He was at this time about fifty-five years old, the foreign officer of the greatest experience and the highest position, and, besides this, a man of wide information, of great intelligence, of agreeable manners, shrewd, practical, even canny, and full of good common sense, a devout Catholic, a staunch royalist, in the highest degree loyal, honest and straightforward. Patrick Gordon was one of the well-known and illustrious family of Gordons; by his mother an Ogilvie, a cousin of the first Duke of Gordon, and connected with the Earl of Errol and the Earl of Aberdeen, he was born on the family estate of Auchluchries, in Aberdeenshire, in 1635." His family being Catholic and royalist, he went abroad at the age of sixteen, and entered the Jesuit College at Brannsberg, but soon tired of the monotonous life, ran away, and found his way to Hamburg, where he met some brother Scots who persuaded him to enter the Swedish Serivce. His life now became that of a soldier of fortune; taken prisoner by the Polish Army, he was not loth to change his allegiance, and later, when retaken by the Swedes he again joined them. He seems to have changed about pretty frequently, but appears to have remained longest with the Poles, with whom he rose to the rank of Captain. When Charles II. ascended the throne, he was anxious to return to his own country, but from this his father dissuaded him; after serving a short period with the Austrians, he was tricked into entering the Russian service by a contract for three years, which, on his arrival at Moscow, was repudiated, the Russian agent who made it being supposed to have exceeded his powers. For a long time the dour Scot refused to take the oath of allegiance, but at last he philosophically settled down and married. Once, on account of his influential royalist connections, he was sent to England on a diplomatic mission to Charles II., and twice he was given leave to go to Scotland, but on each occasion his wife and children were retained as hostages. Gordon was personally acquainted with Charles II., James II. and Queen Christina. He had friends and acquaintances everywhere, and kept up a lively correspondence with them, from whom he received news, wine, scientific instruments and books. In 1699 he died, not without having had a most beneficial influence on the Russian Army, and having been a sort of centre of sweetness and light.

Of course Patrick Gordon was the Gordon par excellence of the Russian Service, but being a good Scot, he never forsook a kinsman. A "History of Peter the Great," by Alexander Gordon, in two volumes, posthumously published in Aberdeen in 1755, three years after the author's death, a delightful and fascinating work, sets forth that Major-General Gordon was the eldest son of Alexander Gordon, of Achintoul, one of the Senators of the College of Justice, and was born on December 27th, 1669. After the Revolution of 1688 he went to France to serve the exiled King, and was sent to Catalonia, where he so distinguished himself that Louis XIV. gave him a Captain's commission, but he did not long remain in the French Service, and managed to rejoin his father in Scotland. In 1692, however, he again departed to seek his fortunes, and went to Russia, where he was befriended by the excellent Patrick of that ilk. The story of how he soundly thrashed six young Russian noblemen, with whom he was carousing, for insulting his country and his countrymen, how they went to complain to Peter, and how Peter instead of punishing him for his temerity, gave him a major's commission, is quaintly and modestly told. Alexander Gordon rapidly rose to the rank of Major-General, and speaks highly of his namesake Patrick, who saved the Emperor's life on a memorable occasion, but he seems to have suffered some inconvenience from the jealousy of Menshikoff, and when, on hearing of his father's death, he became anxious to return to Scotland, Menshikoff facilitated his departure. Alexander Gordon seems to have distinguished himself considerably in Russia, fighting against Mazeppa, the Swedes, and the Poles with conspicuous success. After some vicissitudes, he died in his own country, aged eighty-two, having been twice married, first to a daughter of Patrick Gordon's, and secondly to a Miss Moncrief, but without leaving issue.

A nephew of Patrick Gordon's, Thomas, entered the Russian naval service in 1771, and rose to be Commander-in-Chief of Cronstadt; he died in 1741.

Another very distinguished Scottish name in the Russian Service is that of Greig. Samuel Greig joined the Russian fleet as Post Captain under Catherine II.,

in 1764, and rose to become famous as Admiral Greig. His son, Alexis, was born in 1775, studied for the Navy in Great Britain, commanded the Russian landing expedition in Tenedos; in 1813 he commanded the fleet and helped to blockade Danzig; in 1816 he was made Commander in Chief of the Black Sea Fleet; he died in 1845. These two Greigs may be said to have created the traditions of the Russian Navy. Alexis had a son, Samuel, who, after a distinguished military, and later an administrative naval career, became Minister of Finance in 1874.

In a very quaint book entitled "The State of Russia under the present Czar," by Captain John Perry, London, printed for Benjamin Tooke, at the Middle Temple Gate in Fleet Street, 1716, the author states: "In the year 1698 his Czarish Majesty, being then in England making his observations of our arts in building and equipping out our fleets, among several artificers, etc., whom he was pleased to entertain, I was recommended to him by the then Lord Marquis of Carmarthen, Mr. Dummer (then Surveyor of the Navy), and some others, as a person capable of serving him on several occasions relating to his new designs of establishing a fleet, and making his rivers navigable, etc. After his Majesty had himself discoursed with me, particularly touching the making of a communication between the river Volga and the Don, I was taken into his Service by his Ambassador, Count Golovin, who agreed with me for the salary of 300 l. sterling per annum to be paid me with my travelling charges and subsistence money upon whatsoever service I should be employed; besides a farther reward to be given me to my satisfaction at the conclusion of any work I should finish."

The Volga-Don Canal is thus described:—

"The distance of which communication between the said two great rivers is about 140 Russian miles by the way of two other small rivers, the one called the Lavla, which falls into the Don; the other the Camishenka, which falls into the Volga; upon these small rivers sluices were to be placed to make them navigable, and a canal of near four Russian miles to be cut through the dry land where the said two small rivers come nearest together; which work if finished, would be of very great advantage to the Czar's country, especially in case of any war with the Turks or Crimm-Tartars, or with Persia, or any of the Countreys bordering upon the Caspian Sea."

Captain Perry then describes how this work was first begun by a German called Brickell, a Colonel in the Russian Army and a military engineer. "But," says Perry, "he very little understanding this business which he had taken upon him, and having unaccountably designed the canal, and the first sluice which he placed being blown up, that is, having given way at the foundation, and the water taking its course underneath, at the first shutting of the gates, he therefore, upon his coming to Moscow the winter following, obtained a pass to be given as for one of his servants whom he pretended to send for necessaries for the work, and himself went off with the said pass and made his escape out of the country. The Czar had advice of this whilst he was in England, and therefore he was pleased to send me immediately forward to examine whether the work was practicable or not."

Perry had many troubles with the Tsar's officials, especially of a pecuniary nature. Of these we will not speak. It is sufficient to indicate that Perry seems to have been the first civil engineer to go to Russia, and that, too, at a time before civil engineering had become a recognized profession. His book is both interesting and curious, for he was a close and faithful observer. He performed much useful and ingenious work with the full approval of Peter the Great, of whom he always speaks with the greatest esteem and admiration.

That Perry was efficient at his job appears from the following passage:—

"The fixing of sluices that are to bear but little weight of water, for the making rivers and streams navigable for small vessels for inland carriage, where the floods are not great, is easie and practised everywhere, but I do not know of any river that has before been made navigable of ships of near so great dimensions" (ships of 80 guns) "and the ground where I was obliged to place the last sluice being extremely bad, when I came to dig below the surface of the river, I met with such extraordinary force of springs, that all the pumps that could be placed, could not discharge the water for to carry down the foundation of the sluice to the depth that was required of it, which obliged me to let the works stand still six weeks, till I had made an engine

on purpose for throwing out the water which wrought night and day for several months together, and would easily discharge ten or twelve ton of water in a minute. The Czar happening to come again to Veronize, when I was obliged to use this engine, he came several times to see it work with several of his lords with him, and was extremely pleased with it, being an improvement of an engine which I first made at Portsmouth Dock above 23 years since, when I was Lieutenant of the 'Montague,' that came there to be refitted.''

The work that Perry did was of the first order of importance, he may be described as Russia's first hydraulic engineer, and he seems to have made many canals and regulated many of the numerous rivers of that country.

Captain Perry mentions another interesting fact, and describes how Peter the Great brought over to Russia ''the ingenious Mr. Fergharson,'' and other persons, including a Mr. Gwin, to teach mathematics. Peter the Great caused a large school to be erected in which a great number of boys were taught arithmetic, the most promising being then sent abroad to qualify themselves for the Russian Navy. ''Fergharson'' also taught astronomy, and started an observatory.

Perry further describes how Peter the Great on coming to England, ''resolved to have none but English-built ships made in his country, for which purpose he engaged a number of English ship-builders and artificers for his Navy, the chief of whom was Sir Anthony Dean's son.''

It is impossible to refer to all the British worthies whom Peter the Great attracted to his country to introduce British ideas and methods into Russia. Enough has been said to show how large a part they played in the Westernization of that empire. This does not appear to be sufficiently recognized or appreciated, either in this country or in Russia.

The influence of diplomatic agents hardly comes within the scope of this paper, but mention may be made of that able British representative at the court of the Empress Elizabeth, Sir Charles Hanbury Williams, who was the innocent cause of introducing Poniatovsky to Catherine, and who was largely instrumental in bringing Catherine to the throne, in consequence of the financial assistance he gave her. Pofo Hanbury Williams went mad, and died or a broken heart, having failed to bring about that close alliance with Russia which he fondly believed he could achieve, but Catherine II., like our Queen Elizabeth, was too great a patriot and too wily a diplomatist to consent to have her hands tied.

Speaking of Catherine II. brings us to that remarkable man, Dr. Dimsdale, born in Essex in 1712, who was induced to go to Russia to inoculate the Empress and the Grand-Duke Paul, against smallpox, and subsequently performed this useful service for the best part of the Russian aristocracy. Dr. Dimsdale, who was made a baron of the Russian Empire, and very liberally rewarded besides, found a compatriot in Dr. Vigor, the Court physician. British medical men and surgeons have indeed flourished exceedingly in Russia even down to present times. Alexander III.'s physician was a Dr. Higginbottom, and the chief police doctor of St. Petersburg was for many years a Dr. Duncan.

As a patroness of the arts, Catherine was an admirer of Shakespeare, and a Russian version of Hamlet was actually produced, to which, however, the unfortunate and courtly translater insisted on putting a happy ending, Hamlet marrying Ophelia. Catherine showed her appreciation of British culture by having her grandchildren educated by British nurses and governesses, a custom introduced by her and perpetuated. All the Russian Emperors and Grand-Dukes have been brought up by British nurses and tutors.

One of the most interesting figures in Russian history is Michael Speranski, the statesman who drew up a scheme for a constitution, or a system of representative assemblies, for Alexander I., but, succumbing to the intrigues of dark forces, such as were represented by that curse of Alexander's reign, Araktcheyeff, was exiled to, and later made governor of, Siberia, only to be re-called on the accession of Nicholas I. Of Speransky it is interesting to record that his household was English. He had married an Englishwoman, who died early, but left him a daughter, who was brought up as an Englishwoman by his mother-in-law, who kept house for him and even followed him into exile. In Siberia he showed some kindness to that extraordinary adventurous globe trotter, Captain John Dundas Cochrane, R.N., the author of an entertaining illustrated ''Narrative of a

Pedestrian Journey through Russia and Siberian Tartary.'' That journey was a wonderful achievement and excited much discussion at the time, for the distinguished Scottish traveller conducted his expedition with true racial frugality. Alexander I., as we have seen, was brought up by a British nurse, a Mrs. Hesler, who "gave him his first good manners and tendencies.'' He seems to have felt a veneration for her, which, as La Harpe puts it, did credit to both. La Harpe, by the way, who was nominally Alexander I.'s tutor, had not sole charge, but was merely engaged to teach him literature and liberal ideas. His religious training was entrusted to Samborski, a priest who had married an English lady, a Miss Fielding, and who had lived in London. Alexander I. was always an admirer of English institutions. When in London he was reported to have asked Lord Grey how to create an opposition, to which naive enquiry the caustic Whig statesman is said to have replied: 'If your Majesty will but create a Parliament in your Empire, you will have little difficulty in creating an opposition.'' The court physician of the Emperor was Sir James Wylie.

Alexander I. was so much struck by the work of the Birtish and Foreign Bible Society, that he founded a Russian Bible Society, which distributed nearly half a million copies of the Scriptures. This Society was abolished in 1826, thanks mainly to the efforts of the Metropolitan Photi, but more recently the British and Foreign Bible Society was allowed to step in in its place and to establish branches in Russia.

With the reign of Alexander I., a new era for Russia may be said to have begun, in which British names played an important part. Howard had already visited Russian prisons in the previous reign; indeed, it was at Kherson that he died from camp fever in 1790, and in 1821 we find Wilberforce appealing to Alexander I. on behalf of the emancipation of the serfs. Of the frequent visits of English Quakers and their gracious reception by the Emperor it is unnecessary to speak.

More concrete evidences of British influence are to be found in the erection of the Imperial Mechanical Works by General C. Gascoigne, the erection of a Mechanical Engineering Works by Christopher Wilson in 1802, a firm which was still in existence before the Bolshevik Revolution, and the playing cards works erected by the De La Rues in 1806. The famous Baird Works were founded by Charles Baird in 1810, and continued by his son, Francis Baird, who was born in 1802 and died in 1864. These works built the machinery for the Imperial arsenal, the Imperial glassworks, and made suspension bridges, steam engines for various factories, saw and flour mills, wool, cotton and flax mills, etc. They built some of the first steam propelled vessels ever constructed, and were also concerned in the erection of the Alexander I. column, the St. Isaac Cathedral, the St. Nicholas Bridge and similar works.

One of the most remarkable characters in the Russian service, whose influence, unobtrusive though it was, probably was greater than that of any of his compatriots, was Engineer-General Alexander Wilson, who was born in Edinburgh in 1776, the eldest son of James Wilson, a blacksmith. His education was but sketchy, for in 1784 his father emigrated to Russia, and was employed by Cameron, the architect to Catherine II., to superintend the iron work of the Cameron Gallery, at Tzarskoe Selo. When, in 1790, James Wilson was appointed master-smith to the Government small arms factory, his son was given a post as draughtsman at a small salary.

In 1795, the father and son were at the same time promoted to the rank of officers in the Mining Corps. In 1800, Alexander was engaged as interpreter and secretary to General C. Gascoigne, who was then chief of many of the Imperial mechanical works. In 1803, his father and family left Sisterbeck for Colpino, about twenty miles from St. Petersburg, where Mr. Wilson was appointed resident director's assistant of the works under General Gascoigne. On the death of the latter, in 1806, Alexander Wilson was appointed to succeed him as director of the works at Colpino, and also at Alexandrovsk, on the banks of the Neva. At Colpino, he had the honour of entertaining at tea the then reigning Empress of Russia, Elizabeth, wife of Alexander I., whose knowledge of English enabled her to converse with freedom in that language, and who was induced to visit the place by the empress-mother—Maria Feodorovna, widow of the Emperor Paul.

Then began the most active period of his life; and the variety of works,

mechanical and architectural, planned and executed by him is indeed astonishing. At Colpino he reconstructed the old and constructed new sluices and water wheels; introducing steam as an auxiliary to water power. He built several steamers, supplied them and others with marine engines at a time when these things were novelties even in England. He planned the future town, and supplied it with public schools and dwelling houses for the workpeople, and lived to see a small village grow into a town of 8,000 inhabitants. At the Alexandrovsk works, also formerly a village and now a small town, the activity and genius of Alexander Wilson were no less successful. The original idea of establishing a manufactory at Alexandrovsk was due to the Empress Maria Feodorovna, wife of the Emperor Paul. Her aim was twofold; first, to educate and provide employment for the foundlings of the Imperial Foundling Hospital, when of an age to be discharged from that establishment, and to make them skilful and experienced workmen, able to gain their own livelihood; and secondly, to prepare skilled artizans to carry their arts and knowledge of different manufacturing processes to the remotest parts of Russia. To accomplish this, General Alexander Wilson built an institution for 800 boys and girls. The order, cleanliness and efficiency of this institution made it, as it was intended to be, a model of its kind. General Wilson also constructed extensive mills containing all the improvements known at that time. The large flax mill at Alexandrovsk supplied sail cloth for all the Russian Navy, besides furnishing a large quantity for general consumption, both at home and abroad. Cotton mills, plain and figured weaving looms, mechanical works, etc., were all to be found at Alexandrovsk. In the general superintendence he was assisted by his brother, Mr. Lewis Wilson, until the death of the latter in 1847.

As an architect, General Wilson appears to have possessed good taste, as is testified by the fine structures erected by him at Colpino, Alexandrovsk and other places. While fulfilling his duties at Colpino and Alexandrovsk, he was, on many occasions, employed by successive sovereigns of Russia in undertakings not strictly connected with these places. He cast brass guns, coined copper money, improved anchors and chain cables, built churches and hospitals, and, after personal inspection, reported on the condition and management of different Russian ports, and engineering and mechanical establishments, and was acknowledged to be one of the most honest, trustworthy and able servants in the Imperial Service. He also took an active part and interest in the planning and erection, and management of two large cotton mills, among the original promoters of which were Count Nesselrode and Baron Stieglitz.

Alexander Wilson was, for his many services, successively promoted in 1818, to the rank of Major-General; in 1829, to that of Lieutenant-General, and in 1853, to the highest rank, that of Engineer-General. From 1820 to 1856 he was decorated with four stars of different Russian Orders, the last being that in diamonds of St. Alexander Nevsky, when, by the special order of the Emperor Alexander II., a gold medal was struck and presented to him, with a rescript from his Majesty, to signalize the completion of the fiftieth year of his direction of the Imperial Manufactory of Alexandrovsk, and of the sixty-second year of his service in the empire.

General Wilson, during his eighty-two years' residence in Russia, paid ten visits to England, the first in 1814, during the visit of the Emperor Alexander I., whom he had the honour of attending in many of his inspections of public establishments in this country, and the last in 1862, to the International Exhibition—each time returning home well stored with new improvements and inventions in engineering mechanics and manufactures, and purposing to apply the best of them in his adopted country. Having served Russia under five successive sovereigns, Catherine II., Paul, Alexander I., Nicholas and Alexander II., to all of whom he was personally known, General Wilson retired from active service in 1860, with full pension and, by the special order of the Emperor, the use of the official residence at Alexandrovsk, which he had occupied since 1821, and in which he died, after a very few days' confinement to his bed, on the 13th-25th February, 1866, within two days of completing his ninetieth year. The affectionate esteem with which he was regarded will be seen from the following extracts from a letter from St. Petersburg, describing his funeral procession, the service having been performed in the chapel of the British Factory at St. Petersburg, to which no cemetery is attached.

He was buried in the family grave at Colpino.

"At every village through which the procession passed the clergy and poor turned out, and insisted on carrying the body, the old, grey-headed men struggling to be first. The arrival at Colpino was a perfect ovation. The St. Nicholas church there has a splendid choir; and their chanting and that of the clergy was most solemn and beautiful. Many were in tears; each full of what the General had done for them and their fathers during the fifty years when he was their chief; each had some tale to tell. It appears that when in office at Colpino, he was in the habit of lending them money when they needed it. The people have not forgotten this, or his many other acts of kindness and generosity. He has endowed two schools there; one for fifty girls, another for boys."

The following extract from the "Times" of the 25th June, 1854, will be further evidence of the influence which he possessed with the Government:—

"From the millwright and other engineering departments at Colpino the Englishmen had less difficulty in obtaining their passports, owing to the mediation of General Alexander Wilson, a native of Scotland, who is at the head of that establishment, and who has spent the greater part of a long life (being now nearly eighty years old) in the Russian service, and who is an immense favourite with the Emperor Nicholas. The estimation in which General Wilson is held by the Emperor may be judged from the following incident, which occurred at Colpino, which is the first station on the railway between St. Petersburg and Moscow. On the occasion of the Emperor's visit to the latter city some time since, the General waited on his Majesty at the station, when the Emperor embraced him, and kissed him on the cheek, and declared aloud he was the most honest man in his service."

General Wilson died unmarried, but left nephews and grand-nephews to preserve his name in Russia. One of these, Ivan Ivanovitch Wilson, was the first official statistician in Russia, and organized its statistical service.

It was of General Wilson that Nicholas I. is reported to have said that he, the Emperor and the Tzarevitch were the only three honest men in his dominions.

Space will not admit of a lengthy description of the achievements of British Engineers in Russia, of the public works and waterworks they erected and the enormous influence they exercised in that country. Thus the town of Serpoukhoff is virtually the creation of British engineers, *e.g.*, Hopper, etc. The same is true of the famous Yuzovka, built in 1872 by John Hughes, who may be described as the founder of the mining industry of the Donetz Basin, and who formed the New Russia Company. Candle works, gas works and boiler works were likewise erected by British enterprise. The first cruiser built for the Russian Navy was constructed by the ancestor of the well-known Allan family.

Another benefactor of Russia was Thomas Urquhart, Member of the Institution of Civil Engineers and Locomotive Superintendent of the Grazi-Tzaritzin Railway in South Russia, who died as recently as 1904, and introduced a method of burning oil-fuel in the Grazi-Tzaritzin railway, with the result that by 1884 oil-fuel had supplanted coal over the whole system. Mr. F. V. Urquhart was the actual inventor of the method adopted, which he described in a paper before the Institution of Mechanical Engineers. It is unnecessary to expatiate on the benefits conferred not only on Russia, but on the whole world by this satisfactory practical solution of the use of oil residuals (hitherto waste) as fuel.

Another member of this gifted family, Mr. Leslie Urquhart, is amongst us to-day. His Herculean work in organizing the mining industry of Siberia and Russia on a colossal scale is too well known to need comment.

Our engineers and merchants in Russia have ever acted as unconscious missionaries of friendship and good will, for where a Briton goes in Russia he succeeds in making himself loved and respected. There are no two races that get on so well together as the Russian and the British. Such names as Coats, Ransomes, Mathers and Platt, Pearsons, Vickers, etc., will occur to everybody.

The purely intellectual influence this country has exercised over Russian thought has been incalculable. Shakespeare has been repeatedly translated, the last translation being by the Grand-Duke Constantine Constantinovitch, a grandson of Nicholas I.,

that Emperor who used to read Sir Walter Scott's novels to his wife. The best book on Elizabethan literature, "The Predecessors of Shakespeare," is by Professor Storojenko, whose "Life of Robert Greene" is the only existing complete biography of that eccentric genius, for which reason it had to be translated into English to make it accessible to scholars of this country. The names of Kovalevsky and Vinogradoff are nearly as well known in England as in Russia, and Mr. Milioukoff is as great an authority on English Constitutional Law as any living British lawyer, Lord Bryce always excepted.

Tourgueniev has admitted that it was from Maria Edgeworth that he got his first inspiration to write his "Sportsman's Notebook," which roused public opinion against serfdom, and led to such a wonderful series of brilliant and immortal works of art. Pushkin is so completely saturated with English literature that, when reading him in the original, one seems to feel the presence of the ghosts of his great models, Shakespeare, Sir Walter Scott and especially Byron. Lermontoff is a mixture of Byron and Keats, with a dash of Thomas Moore. Pushkin's immediate predecessor, Joukovsky, the romantic poet who imitated Scott, and was the tutor of Alexander II., was as Anglophil as any Russian could be. When we examine the methods of Count Leo Tolstoy, we cannot fail to trace the influence of English novelists, particularly Thackeray and George Eliot. Gogol again has been called the Russian Dickens.

But the two writers who were most widely read in Russia, at a time when they were barely appreciated in England, were John Stuart Mill and Herbert Spencer. It is pathetic to reflect how the ingrained love of liberty of these two doctrinaire writers appealed to the passionate longings of the awakening Russian Intelligenzia.

But it is not only our literature which appealed to the Russians, our educational system was quite as much an object of envy as our political institutions. The old conservatives of Moscow even attempted to copy our public schools, and under the patronage of Alexander III., then Heir Apparent, the Lyceum was founded. Unfortunately, the founders had not the courage of their opinions; they were afraid to go the whole hog, and introduce prefects and abolish ushers. To leave the boys to themselves without supervision seemed too great a risk, and so the famous Lyceum soon sank to the level of an ordinary gymnasium. Mr. Aylmer Maude spent some time at this school, but did not find it congenial.

Two British names are especially identified with Russia, Sir Donald Mackenzie Wallace, who died last year, and Sir Bernard Pares. Sir Donald Wallace I had known since my boyhood, for it was at the house of my sister's godfather, Michael Nikolaievitch Kapoustine, that he wrote his famous book on Russia, which, after having been prohibited by the Russian Government, was later adopted as a text-book in Russian schools. Sir Bernard Pares is still with us, and a very active force.

The trade relations between this country and Russia have of recent years been somewhat under a cloud, for which the British merchant has been rather unjustly blamed. In the days before the Crimean War, our share of Russian trade was about one-third of the total turnover, but thanks to the gradual growth of German industry and commerce, and the proximity of that country to Russia, this proportion steadily dwindled in favour of Germany. The German Commercial Treaty was almost a death-blow to British trade in Russia but, in spite of this and many other adverse circumstances, British merchants still retained the largest share of Russian trade after Germany.

DISCUSSION.

THE CHAIRMAN (The Right Hon. Lord Carnock), in opening the discussion, said he thought he would be expressing the opinion of everyone present when he said they had just listened to a most interesting paper, which, he thought, might be termed a *catalogue raisonné* of British people who rendered important services to Russia at various periods in her history. On the walls of his study in the British Embassy at Petersburg, there used to be a large collection of engravings from prints representing the portraits of the envoys who had left England to be accredited to the Russian Courts. They began with a portrait of Lord Howard, of Effingham, in the reign of Queen Elizabeth, and continued, with a few gaps, right down to the present time. That collection, he was afraid, had disappeared in the welter of events which had occurred in the last few years. There were amongst those envoys some eminent men who had, doubtless, exercised considerable influence within their sphere of action, namely, the Courts and Governments to which they were accredited. During his career abroad he had realised more and more

that if one wished to establish a friendship between two countries on a really durable and sound basis one must go a good deal beyond merely bringing about amicable relations between the Governments of the two countries, even if those relations were strengthened by Treaties and Conventions. It was really essential that the people of those countries should come into close contact with each other and begin to understand each other and find that they had interests in common. He thought there was no better means of attaining those ends than by promoting and developing commercial intercourse. In 1907, when Great Britain had settled her political divergencies of opinion with the Russian Government, and the official relations between the two countries became very amicable, he was glad to see a gradual tendency to develop the already considerable volume of trade between the two countries Intercourse became more frequent, deputations arrived here from Russia, and we even had the Russian Ballet—in fact there was much interest awakened in this country in all matters concerning Russia. The volume of trade, which was already considerable, showed signs of rapidly increasing. There was, of course, competition from Russia's western neighbour, which was inevitable, owing to Germany's propinquity, the network of agencies she had over Russia, and her thorough understanding of the requirements of the Russian people. However, all was going well between Great Britain and Russia at that time, and, personally, he had very great hopes then of seeing matters go even beyond the hopes and dreams of the gallant adventurers of the sixteenth and seventeenth centuries. Then, unfortunately, came the War, then the crash, and Russia was strewn with wreckage of every description. He need not go into that very sad part of the history of Russia, of which we were still seeing the course of events. He had heard that there was a desire to resume trading relations, but if there was any such resumption, he was afraid it would have to be on a very limited scale indeed. Factories had been destroyed or shut down, large estates were left derelict, and transport was in a state of absolute chaos. The intellectual classes of the population had been ruined or murdered or had disappeared. In fact, he was afraid credit had been absolutely shattered, and it must be some considerable time before any real improvement could be brought about. He had every confidence, however, that before entering into any definite arrangement with Russia the authorities in this country would ensure that any engagements that were made would be faithfully carried out, and he also trusted that they would see that past obligations were also recognised and acknowledged; otherwise it would be like trading with an undischarged bankrupt.

Col. Nicholas T. Belaiew, C.B., said he wished to express his gratitude to the author for the excellent manner in which he had described the personal influence of Britons in Russia. He would like to add his tribuute to the work of Sir Roderick Murchison, whose work in connection with the geology of Russia led General Anossow to make his investigations with regard to some gold mines in the Urals and further east. It was also due to Murchison's influence that the first copies of a certain Russian journal were issued not only in Russian, but also in the French language, so as to make them accessible to the Western world. He thought there was one general reason why it was always possible for the English and the Russians to settle down together so peacefully and to come to such a good understanding in all respects, *i.e.*, the Norman influence. That influence was powerful in Russia, between the eighth and tenth centuries, and one or two centuries afterwards the Normans made their appearance on the shores of England. There were many things in the customs of Russia and England which were due to the Norman influence. Certain measurements which the Normans introduced into England and Russia were still in existence in Russia, and it was interesting to note that certain Norman churches in this country, for instance, in Devonshire, were built not in feet, but in arshines and sajens. With regard to Russian trade with Great Britain and Germany, he would like to draw attention ito the importance of the continuity of frontiers. That factor was a powerful German ally. On the other hand, as long as Russia had free access to the sea, especially to the Baltic shores, the same continuity of frontiers with Great Britain, the Mistress of the Seas, was assured; so in the old days, when the main part of the trade with Great Britain was conducted by Petrograd, the English had a large community in Kronstadt, and it was only when the trade ceased to go from London to Kronstadt that the German influence became powerful. If the English ships, instead of carrying goods to Hamburg and via Hamburg to Russia, would go direct from London to Petrograd, as in the old days, then the British influence would be re-established in Russia.

Lieut.-Col. C. Tennyson said he would like to point out an omission which the author had made—probably intentionally—in his paper: Mr. Brayley Hodgetts had omitted to introduce his own name into the long list of those British men who had made the name of Great Britain and British ideas very popular in Russia. The author was well known in Russia; he had lived there for many years and had done his best to show this country what Russia was and what the English people ought to think of Russia and Russian history. He had also written

many articles and historical works about Russia which were of very great importance. The large number of British people who had been living in Russia—he believed some were there still; he hoped they would all return safely to this country—had been a very powerful link between the two countries. The extraordinary sympathy and love they felt towards their adopted country was very touching. Every Russian who was now in England saw that almost every day. The feelings of the English people who had returned from Russia were as sympathetic towards Russia as those of the best Russian patriots could be. The Russians would never forget that in the present time of distress the English had been more friendly towards them than perhaps any other nation. There were many people who went to Russia in order, as they said, to find out the truth about Bolshevism, but most of them did not know the language of the country and had never been there before; they spent a few days in Russia and then came back and related the most startling stories about the conditions there. At the same time there were in Great Britain hundreds of clever and honest people who had just come back from Russia after living there for many years; a great many of them were born in Russia; they knew the country well. Why did not the British Government or the British Parliament or the British public take notice of what those people said? They knew all that it was necessary for anybody in this country to know. He hoped that the Government, Parliament, and the British people in general would soon pay more attention to what the British residents in Russia would tell them about Russia and about all that was going on in that country at the present time. That, he thought, would be of benefit to both countries.

The Rev. Arthur Cazalet said it might be of interest to some of those present to know that for some years there had been in existence a Society which had been trying to bring the literature of Great Britain and Russia together and to make English people really understand the beauty and the force of Russian literature, and had also given an opportunity to those Russians who were at present living in this country to learn more about English literature. The name of that Society was the Anglo-Russian Literary Society. It held meetings every month, and had met on the previous day at the Imperial Institute. It was very important that the beauty and force of Russian literature should be appreciated at the present time, when there was such a danger of the intelligenzia in Russia being practically wiped out of existence.

Mr. F. H. Skrine said the paper had been a most delightful one and must have involved an immense amount of labour. It was really a series of thumbnail sketches of our great countrymen who had done so much for the evolution of Russia. It was a revelation to him to hear that the Scots had had so much to do with Russia. There was no doubt that one did meet Scotsmen everywhere, but he really had not been aware until the author mentioned it that Peter the Great was partly Scots. There was a story of a number of Scotsmen meeting together, and one of them remarked that whatever great men there had been they had always been Scotsmen; there had been no great men except Scots. An Englishman present said: "How about Napoleon?" "Well that is true," was the reply, "Napoleon was not a Scot, but he had all the ability of the Scots!" He thought it would be agreed the Emperor Peter the Great had an extraordinary amount of Scottish ability. It was interesting to study the psychological aspect of the subject under discussion. In Western Europe everyone was born in civilisation, so to speak, and went through life picking up and accumulating a mass of prejudices which formed a kind of crust round him that it was very difficult to penetrate. The result was that when a man came to the front in England it was sometimes by his ability, but it was much more likely to be by luck or self-advertisement or intrigue. The Russians, on the other hand, were a very primitive race, absolutely unspoiled by civilisation, and they were easily penetrated by the personal equation. The English had just those qualities which the Russians lacked. They were as a rule honest—at least compared with the Russians; they had great organising power, enormous energy and strong commercial instincts. Those were the very qualities which the Russians did not possess. That was really the cause of the fortunes that were made in Russia by Englishmen; he had never heard of an Englishman with a fair amount of business ability and honesty going to Russia who did not make his fortune. He hoped and trusted that when the horrible Bolshevik storm cloud had rolled away from that unhappy and suffering land, British people would again occupy the great place they had held for centuries in Russia.

On the motion of the Chairman, a hearty vote of thanks was accorded to the author for his interesting and illuminating paper.

Mr. Brayley Hodgetts, in reply, said he had been rather disappointed in the discussion, as he had hoped that people would have got up and abused him for not including in his paper the name of somebody they knew about connected with Russia, and thus have added to the completeness of the paper. On the other hand, Mr. Skrine had made a delightful speech, in which he had opened up a beautiful vista of the future prospects of trade between

England and Russia, when the honest Englishman would go over to Russia and spoil the dishonest Russian.

The meeting then terminated.

BARON ALEXANDER MEYENDORFF writes, drawing attention to the literature published on this subject. In a book by Sir G. S. Clarke, now Lord Sydenham, entitled "Russia's Sea Power, Past and Present, or the Rise of the Russian Navy," London (Murray), 1898, the author states that owing to the great infusion of British Officers in 1780, the Russian Navy was not in a position to undertake hostilities against this country.

In "An Authentic Narrative of the Russian Expedition against the Turks by Sea and Land (1770)," compiled by an officer on board the Russian Fleet, London (S. Hooper), 1772, it is said that "all Europe was surprised and alarmed at seeing for the first time the Russian flag flying among the islands of the Archipelago chasing the Turks."

Admiral Sir Cyprian Bridge published in 1899 a "History of the Russian Fleet during the Reign of Peter the Great by a Contemporary Englishman (1721)." This was printed for the Navy Record Society.

Another useful work of reference is "Scottish Influence in Russian History from the end of the XVIth Century to the beginning of the XIXth Century," by Francis Stewart, Glasgow (Mackholl), 1913.

Much interesting material is also contained in "The British Colony in Russia," by C. L. Johnston (author of "Science, Art and Literature in Russia"), London, 1900.

MRS. E. EVELYN EASTLAKE desires to suggest another name to be added to the many given by Mr. Brayley Hodgetts as personally influencing Russia, that of Dr. Herbert Bury, Bishop of Northern and Central Europe, whose love for, and loyalty to, Russia is almost wonderful. This can be learnt not only by reading his book, "Russian Life To-day" (published in 1914), but from conversations with Russian and English engineers and others who were fortunate enough to meet him in Russia from time to time. At the little Church, St. Peter's, Vere Street, W., which was in charge of the Bishop during the War, owing to his being unable to visit the Continent officially, the worshippers were asked, Sunday by Sunday, to keep Russia ever in their mind; and they were taught to reverence Russia and her people. He is a great optimist, and always makes one feel Russia will recover because he is so certain of it himself.

Further, Mrs. Eastlake mentions Sir Boverton Redwood, who loved Russia and her people. He knew the late Czar intimately, and was constantly sent for by him in connection with oil questions and oil policy. Sir Boverton was a member of the Russian Technical Society, and was largely connected with the pioneer work of the Baku Oilfields; until his death he advised the big English companies. She adds: "I could name many Russians with whom he worked to establish the oil industry of Russia. Sufficient is it to mention old Professor Mendeléeff and the Nobel Bros.—especially Ludwig—who were associated with him in the early development of the Russian oilfields. He was a personal friend of Mr. Leslie Urquhart."

GENERAL NOTES.

THE RUSSIAN ECONOMIST.—The newly-formed Russian Economic Association has been founded in London with the object of collecting and preparing economic information in preparation for the day when Russia may again become a producing centre and conduct trade with other countries. The Association has now produced the first number of *The Russian Economist* (printed by Williams, Lea and Co., Ltd., 12*s.* 6*d.* net), which is to appear every two months. The first number contains ten papers by members of the Association, and an eleventh unsigned article on the economic situation in Russia in 1919. The papers are published both in Russian and English, the latter language having been chosen in preference to French or German, because nowhere is so much work being devoted to the solution of the world's economic problems as in Great Britain and the United States. The *Journal* is excellently produced, and will no doubt prove of great value to all interested in studying the economic condition of Russia.

THE PHYSICAL SOCIETY AND OPTICAL SOCIETY'S ANNUAL EXHIBITION. — This Exhibition, which is to be held on Wednesday and Thursday, January 5th and 6th, 1921, at the Imperial College of Science, South Kensington, will be open in both the afternoon (from 3 to 6 p.m.), and in the evening (from 7 to 10 p.m.). Sir W. H. Bragg, K.B.E., F.R.S., will give a discourse on "Sounds in Nature," at 4 p.m. on January 5th. Emeritus Professor Archibald Barr, D.Sc., LL.D., will give a discourse on "The Optophone—an Instrument which enables the totally blind to read ordinary print," at 8 p.m. on January 5th, and at 4 p.m. on January 6th. After the Discourse, a demonstration will be given by a totally blind person. At 8 p.m. on January 6th, Professor C. R. Darling will give a discourse on "Some unusual Surface Tension Phenomena." All the lectures will be illustrated by experiments About 50 firms will be exhibiting, and a number of experimental demonstrations have been arranged. Admission in all cases will be by ticket only. Those interested should apply for tickets to F. E. Smith, F.R.S., Hon. Secretary of the Physical Society, National Physical Laboratory, Teddington, S.W.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

JANUARY 12.—CHARLES S. MYERS, M.D., Sc.D., F.R.S., Director of the Psychological Laboratory, and Lecturer in Experimental Psychology, University of Cambridge, "Industrial Fatigue." (Aldred Lecture.) W. L. HICHENS (Chairman, Messrs. Cammell, Laird and Co., Ltd.) in the Chair.

JANUARY 19.—F. M. LAWSON, Assoc. M.Inst.C.E., "The Future of Industrial Management." SIR ROBERT A. HADFIELD, Bt., D.Sc., D.Met., F.R.S., in the Chair.

JANUARY 26, at 4.30 p.m.—A. ABBOTT (Department of Scientific and Industrial Research), "The Origin and Development of the Research Associations Established by the Department." W. GREENWOOD, M.P., Vice-President, British Cotton Industry Research Association, in the Chair.

FEBRUARY 2.—A. F. BAILIE, Chief Engineer, Technical Department, Anglo Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World." PROFESSOR SIR JOHN CADMAN, K.C.M.G., D.Sc., in the Chair.

FEBRUARY 9.—WILLIAM ROTHENSTEIN, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England."

FEBRUARY 16.—WILLIAM CRAMP, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice."

FEBRUARY 23, at 4.30 p.m.—SIR DANIEL HALL, K.C.B., F.R.S., Permanent Secretary, Board of Agriculture, "The Present Position of Research in Agriculture." (Trueman Wood Lecture.) Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the Chair.

INDIAN SECTION.

Fridays at 4.30 p.m.

JANUARY 21.—R. S. TROUP, M.A., C.I.E., Indian Forest Service, Professor of Forestry at the University of Oxford, "Indian Timbers." SIR CLAUDE H. A. HILL, K.C.S.I., C.I.E., in the Chair.

FEBRUARY 18.—Paper to be announced later.

APRIL 22.—Sir George Birdwood Memorial Lecture.

MAY 27.—WILLIAM RAITT, F.C S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

COLONIAL SECTION.

At 4.30 or 5 p.m.

MONDAY, JANUARY 3, at 5 p.m.—FRED C. CORNELL, O.B.E., "The Alluvial Diamondiferous Deposits of South and South-West Africa." MAJOR SIR HUMPHREY LEGGETT, R.E., D.S.O., in the Chair.

TUESDAY, FEBRUARY 1, at 4.30 p.m.—G. C. CREELMAN, LL.D., B.S.A., Agent-General for Ontario, formerly Commissioner of Agriculture and President, Ontario Agricultural College, "Modern Agriculture."

INDIAN AND COLONIAL SECTIONS.

(Joint Meetings.)

At 4.30 p.m.

FRIDAY, MARCH 4.—WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

TUESDAY, MAY 3.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

HOWARD LECTURES.

ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E., "Aero Engines." Three Lectures. January 17, 24, 31.

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures, February 14, 21 and 28.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.C., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

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FRIDAY, JANUARY 7, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 12th, at 8 p.m. (Aldred Lecture). CHARLES S. MYERS, M.D., Sc.D., F.R.S., Director of the Psychological Laboratory, and Lecturer in Experimental Phsycology, University of Cambridge, "Industrial Fatigue." W. L. HICHENS (Chairman, Messrs. Cammell, Laird and Co., Ltd.) in the Chair.

Further particulars of the Society's Meetings will be found at the end of this number.

COLONIAL SECTION.

MONDAY, JANUARY 3rd; MAJOR SIR HUMPHREY LEGGETT, R.E., D.S.O., in the Chair. A paper on "The Alluvial Diamondiferous Deposits of South and South-West Africa," was read by MR. FRED. C. CORNELL, O.B.E.

The paper and discussion will be published in the *Journal* of January 21st.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary

CASES FOR JOURNALS.

At the request of several Fellows of the Society, cases have been made for keeping the current numbers of the *Journal*. They are in red buckram, and will hold the issues for a complete year. They may be obtained post free, for 7*s*. 6*d*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FIFTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 15TH, 1920.

In the unavoidable absence of Lord Selborne, the chair was taken by COLONEL GEORGE LOYD COURTHOPE, M.P. (President of the English Forestry Association).

THE CHAIRMAN, in opening the meeting, said he very much regretted that Lord Selborne was unable to be present, because it was due to Lord Selborne's action that the Acland Committee was appointed, upon whose universally accepted Report the Forestry Commission had come into existence. The nation was very fortunate in having secured the services of Lord Lovat, than whom no one was more respected and trusted in the forestry world, as the first Chairman of the Forestry Commission.

The following paper was then read :—

FORESTRY.

By MAJOR-GENERAL THE RIGHT HON. LORD LOVAT, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O.

Eighteen months ago Great Britain stood alone amongst the nations of Europe, a State without either a forest policy, a forest authority, a survey of its waste lands or an estimate of the extent of, or the yield from, its privately owned woodlands. Except for a few hundred acres planted with Development Fund monies, the State possessed no forest of its own; it had in consequence no established forest customs, no forestry code, no personnel with experience of State forest management, and no area in which a complete rotation of conifers or hardwoods grown under proper sylvicultural management could be found.

It can be easily realised that under these circumstances the Forestry Commission's first year of work has been no ordered advance along well-defined paths of progress, but rather a series of improvisations to meet the exigencies of the moment, and an attempt to get something practical done.

I propose to deal later with the first year's work of the Commission, but I would like to say one word of appreciation of the "spade work" done by Departments and Committees both before and during the war.

Up to the time of the Great War the various Departments vicariously charged with forestry had used such small sums as had been alloted to them to the best advantage, and many preliminary steps for the furtherance of forestry education, research and experiment had been carried out.

The Office of Woods and Forests stimulated by the keenness of the late Sir Stafford Howard had from 1893 onwards inaugurated a planting policy in some of the more important Crown woods under recognised sylvicultural conditions, and on a larger scale than that which had obtained in the woods of private owners after the agricultural boom of 1860-75.

At a very early stage of the Great War it became evident that circumstances might arise which would necessitate the nation having to take the choice between starvation and surrender of military effort abroad on account of the lack of timber supplies.

In 1916 Lord Selborne, then President of the Board of Agriculture, always a keen protagonist of an adequate Forest policy, realised that the time of awakening of the forestry conscience of the nation was the time to define once and for always—

(a) What was wanted in the way of a forest policy to make England safe in time of emergency.

(b) What executive steps should be taken to give effect to such a forest policy when defined.

A Committee was accordingly appointed, and as a direct result when the Reconstruction Ministry was formed, a Reconstruction Forestry Sub-Committee under the Chairmanship of Mr. Acland, with Mr. Robinson as Secretary, carried on an enquiry under the following reference:—

"To consider and report upon the best means of conserving and developing the woodland and forestry resources of the United Kingdom, having regard to the experience gained during the war."

The Reconstruction Forestry Sub-Committee had no difficulty in coming to a unanimous decision on the main points.

(1.) That to ensure the timber supply of Great Britain in time of war or national emergency, the 3,000,000 acres of existing woodlands must not only be conserved, but rendered more productive, and that 1,770,000 acres of previously unplanted land must be afforested by the State.

(2.) That to carry on the first 10 years of the national forest policy £3,500,000 would be required:—

(a) To afforest 185,000 acres of previously unplanted land.

(b) To re-afforest 85,000 acres of previously afforested land.

(c) For establishment charges, education and research.

The main decisions of the Committee were accepted by the Cabinet, a Bill was drafted to give the necessary power and vote the first block grant; the Bill was accepted by the various parties on both sides of the House, and, subject to certain amendments, retaining Parliamentary control over expenditure, was passed on August 13th, 1919, as an agreed measure.

Three points in this connection are important:—

(1) That not only the Cabinet, but Parliament are committed to the principle of a forest policy, having an adequate supply of timber in time of emergency as its objective.

(2) That Parliament is committed to the principle both to the planting up of old afforested lands and to the afforestation of new lands for which a sum of £3,500,000 has been voted for the first 10 years.

(3) That the estimates for the executive work in the first ten years are based on 1916 figures, which have no relation to the cost of material or personnel to-day.

Having outlined in the briefest manner possible the "*point de depart*" and the forest policy of the nation, may I be allowed to touch on three questions of general interest and then give a brief summary of some of the Commission's work in 1919-20:—

(1) The part which private forestry should play in the forest policy of the State.

(2) Questions affecting the acquisition of land for forestry.

(3) The relation of forestry to small holdings and soldier settlements.

The Part Which Private Forestry Should Play in the Forest Policy of the State.

It is of the greatest importance to the State that private owners and corporate bodies should be induced to maintain the same acreage of land under timber as they maintained before the war.

As Director of Forestry in France with unique opportunities for studying timber production in Western Europe in 1917-18, I have no hesitation in saying that but for the patriotism and foresight of private landowners and others who planted or owned 97% of the woods in Great Britain, it would have been impossible to maintain the supply of timber for the troops in France or at the bases or centres of production in Great Britain.

The national forestry policy of insurance against timber famine "by the creation in the forests of store houses of timber against periods of emergency" is based on the maintenance of area with an increase of yield from privately owned woodlands. If private forestry fails to produce its quota the additional cost to the State in planting and acquisition of land will amount to not less than £27,000,000 in the course of the next 60-80 years, a not unimportant sum in these years of financial stringency.

A further reason why the maintenance of private forestry operations is of importance to the nation is that the timber situation in Great Britain to-day is much more unsatisfactory than most people imagine, and that concerted effort is necessary if we are to avoid shortage in the near future.

We have no survey of the woods in Great Britain and Ireland and no accurate knowledge of area, annual increment or average production.

I would hazard the opinion, based only on personal observation and reports from men whose business it is to study special areas:

1. That a very large proportion of the best stocked coniferous woods over 20 years of age have been felled or thinned out to such an extent as to be no longer productive.
2. That near the mining centres the saleable woods over 30 years of age have practically ceased to exist.
3. That in certain parts of the country—notably in Ireland—the purchase of land by farmers and small holders has led to the destruction of many of the smaller woodlands and most of the best hedgerow timber.
4. That of the 3,000,000 acres of woodlands existing before the war, probably less than 750,000 acres are fully stocked with "high forest timber" between 15 and 70 years of age.

To face this very serious position and to carry out the policy laid down by H.M. Government, the Forestry Commission have taken, or are taking the following steps to induce private owners and corporate bodies to plant.

Education. Forestry education for land owners and land agents is to be subsidised by the Forestry Commission at six or seven educational centres.

The education of foremen and working foresters is now being carried on at seven schools in Great Britain and Ireland. It is hoped not only to educate men for the State Service, but also in time to educate the sons of foresters, foremen and forest workers employed in private estates, who will return to private forestry when well grounded in theoretical as well as practical knowledge.

Advisory Work. The divisional organisation in Great Britain and Ireland has been completed and the District Officers are takng up their duties. The advisory work done by the Commission is already important. Working plans have been made for estates and advice given on sylvicultural questions generally. Regulations and a scale of charges for advisory work are now being considered, the general object aimed at being that charges will be made for out-of-pocket expenses and that advice will be available on all sylvicultural subjects other than the actual valuation of standing timber.

Research. Certain bulletins and leaflets of value to private planters have already been issued.

The increased cost of establishing plantations is one of the main reasons why the private planter has not re-afforested felled areas. We hope before next planting season to issue a bulletin with a summary of existing information and a report of experiments which have been or are being conducted to keep down working costs; the bulletin will include—

1. Notes on the purchase or the provision of seeds at home and abroad, on the cheapening of nursery work, including methods of sowing, labour

saving devices for weeding, lining out, etc. Reports on experiments in State nurseries.

2. Suggestions as to how money can be saved in the preparation of land for planting, including such questions, as cleaning up "slash," burning, drainage, the treatment of peat land, fencing, preservation of fencing posts, reports on experiments made on land only partially cleared from "lop and top", undergrowth, etc.
3. Methods of planting and tools suitable for various soils. The spacing of plants, with records of experiments of extended plant spacing and how far distances are limited by exposure, plant cleaning and the early covering of the soil.
4. Reports on observations and experiments on thinning designed to shorten the rotation of crops.

While educational, advisory and research work should increase the chances of success and reduce the cost of operations, it cannot be hoped that it will be possible in the near future to get back to pre-war costs for establishing plantations. In addition to what has been mentioned above, the Forestry Commission, as authorised by Statute, are giving certain grants and entering into profit-sharing schemes. The regulations for grants and profit-sharing schemes have been discussed with Consultative Committees and have now been issued in draft form.

Whether the encouragement offered will or will not be sufficient to induce private owners to re-afforest the whole of the 3,000,000 acres maintained under forest before the war, time alone will show. One thing can be stated with confidence that, if any landowners or public bodies are in a position to re-afforest their land, now is the time that they can do so with the maximum of benefit to the State.

Questions affecting the Acquisition of Land for Forestry.

As I have already shown, Parliament has decided that to safeguard the timber supply in times of emergency, it is necessary not only to conserve the existing forests, but also to create new State forests on ground not previously planted.

I wish to insist on this point, as it is one which is not always recognised, viz.: that the afforestation of land not previously afforested is not a decision of principle by the Forestry Commission, but an executive act, based on a decision to which all the parties of the State are committed.

In going into this matter in some detail, I hope that I shall not be considered as developing unduly a single facet of the forestry question. I am satisfied that the cry of "mutton *v.* trees," "food of the people *v.* timber production," if not to-day, certainly in the near future, may be made use of by interested parties, who may, but who equally may not, regard the advantage of the State, as their first consideration.

I would ask you to consider firstly a few basic facts which will result from the Government planting policy and, secondly, to consider the various types of land which will be affected.

(1.) Even supposing that the whole of the land taken for the creation of State forests (1,770,000 acres) were taken from grazing lands, the reduction in the meat yield in Great Britain and Ireland would only be 0.7%, or if we include imports, 0.4%. Further, this reduction will not come into full effect until 60 to 80 years from now, which—unless I am unduly optimistic—should give ample time, by draining, bracken cutting, etc., to improve grazing areas and make good the loss.

(2.) During the first decade the total area of grazing land in Great Britain will hardly be affected:—

(*a*) Because the surplus grazing land set free for sheep in deer forests (after the planting land has been taken for afforestation) will to a great extent make good the area taken from sheep farms.

(*b*) On the sheep farms which are taken for planting purposes the blocks planted each year will, as a rule, not exceed 1/20th of the total acreage of the farm. It may also be argued that the loss of food from the grazing land will, in many cases, be compensated in part by the establishment of small holders on the previously unworked arable land.

(3.) In many parts of the country sheep are considered to have a "hefted" or acclimatised value. It is not probable that a Government Department, if wisely administered, will plunge into sheep stock on a large scale on what would appear to be a falling market. (N.B.—Some of the cross

breed wools have fallen 30 to 40% ; black faced wool is at present unsaleable at 3d. to 4d. per lb. There has been an appreciable drop in mutton, and imported mutton is about 25% cheaper than this time last year.)

Types of Afforestable Land.

For afforestation purposes land may be divided into four classes :—

(1) Arable land.
(2) Common grazing land.
(3) Land devoted wholly or mainly to sport.
(4) Hill grazing land.

1. Arable Land.

Arable land, *i.e.*, land either under the plough or suitable for agriculture, can, and should be, put to more important economic uses than afforestation. Speaking generally arable land gives a larger bulk yield per acre, the product from the land is more valuable, the land employs more men per cultivated acre, and has a higher assessable value than it would have were it used for sylviculture. Arable land should, therefore, only be taken for forestry :—

(*a*) For the establishment of nurseries (some hundreds of acres in the whole of Great Britain and Ireland).
(*b*) For the establishment of forest workers on small holdings.
(*c*) For works in connection with forestry (mill sites, etc., where no other suitable land is available).

2. Common Grazing Land.

Common grazing land is in the same way, to a great extent, outside the scope of forestry development. I do not propose to go at any length into this question to-night. I would only say that it would probably be advisable for even the best intentioned Government Department to act with caution and forbearance, and only enter into this particular storm centre after the possibilities of acquiring land from other sources have been exhausted.

Method of occupation rather than economic value must be the dominating consideration in acquiring land of this kind.

One of the main objects of forestry is to increase the resident population in rural districts. It would be folly to touch fully stocked grazings where the out-runs for cattle, both in the summer and winter months, is essential to the smallholders, and where the common grazing often pays an important portion of the rent.

Common grazings, not fully stocked, where the grazings of a few badly conditioned sheep give a small free return to people not primarily interested in agricultural pursuits, is quite another matter. In common grazings of this kind, the land is often neglected, undrained, bracken-covered in the lower, and exposed on the higher slopes. In many cases it may be possible to pay a fair rent and afforest a portion of the grazing, improving the remainder by shelter from the woods created, and by putting the rent back in to the unplanted portion in the form of draining and bracken cutting.

I have in my mind a bracken covered farm in the South of Scotland, where the proprietor has taken one-third of the wintering for planting, charged for the afforested portion an economic rent, and devoted the rent to bracken cutting in the unplanted ground, thereby making the residual two-thirds of wintering land capable of carrying as much stock as the whole area carried previously.

It remains to be seen whether intelligent treatment of the great tracts of poorly grazed commonage in the South and West of Great Britain is possible. Prejudice and ill-defined rights will undoubtedly be a difficulty; nevertheless, some of the best planting land in Great Britain is not "pulling its weight," either in food or timber production to-day, and the question will have to be tackled in due course.

3. Land Devoted to Sport.

Deer Forests.—Deer forests comprise the greater portion of the 4—5,000,000 acres in Great Britain wholly or mainly devoted to sport. They probably extend to over 3,000,000 acres and are mainly situated in the Highlands of Scotland.

It is calculated that deer forests contribute 1 lb. per acre per annum to the nation's food supply. This calculation is based on the returns of certain groups of forests taken from the Venison Committee reports in the Great War, as well as from the returns from individual forests.

Employment.—The employment on deer forests, judging from the reports of the '73, '83 and '92 Commissions, is rather greater than the amount of labour employed on a corresponding acreage of sheep farm land.

Rent. The average acre of deer forest is worth something between 1*s.* 6*d.* and 2*s.* 6*d.*, depending on accessibility, amenity

and sporting possibilities rather than on the grazing or sylvicultural value of the land.

Arable Land. The amount of arable land to be found in deer forests is relatively small. At the time of the 1892—4 Commission, when deer forests extended to about 2,500,000 acres, the acreage of arable or old arable land was under 3,000 acres. No return has been made since that date, but with the extension of deer forests by about one-third, it is probable that the area of agricultural land has increased in at least an equal proportion. This point is important when considering the question of small holdings in connection with afforestation.

4. Hill Grazing Land.

A considerable extent of hill grazing land, downland and improved pasture must be ruled out, in the same way that arable land is ruled out as being too valuable for forestry.

Except under specially favourable circumstances it has not paid in the past, and it will probably not pay in the future to afforest large tracts of land worth over 5*s.* per acre per annum.

A great deal of hill land suitable for forestry exists, which is let at from 2*s.* to 6*d.* per acre, according to both the Erosion and the Re-construction Sub-Committees' reports, produces anything from 11 lbs. to 2 lbs. of meat per acre per annum.

Land of this sort includes black faced ewe hirsels in Scotland, carrying one sheep to 4—5 acres where allowing for deaths, low average lambing returns, allowing further for lambs and gimmers wintered on the low ground, the average return is from 2—3 lb. of mutton and 1 lb. of wool. It also included hill farms, carrying a sheep to the acre or acre-and-a-half where the death rate is low, and the young sheep can be wintered on the hill, and where the return of mutton runs to upwards of 11 lb. per acre per annum.

Employment. As to employment on a sheep farm, figures vary with the number of sheep carried per acre, the amount of fencing, the amount of arable land in cultivation, etc. One man to 500 acres up to one man to 2,500 acres would cover the figures of employment on many hill farms.

The value of the product from unimproved hill grazing, calculating mutton at an average price of 2*s.* to 1*s.* 6*d.* per lb., and the wool 2*s.* to 10*d.* per lb., might be anything from £1 10*s.* to 5*s.* per acre per annum.

5. Economic Value of Hill Grazing when Planted.

The returns from afforested ground vary just as widely as the returns from land under sheep. Bulletin No. 3, recently published by the Forestry Commission, shows that results from the 1,100 plots and sub-plots at present under observation vary from 160 cb. ft. per acre per annum, in the case of first class Douglas fir land, down to under 50 cb. ft. per acre per annum from third class Scots pine land. If we take an average block of land which includes poor soil suitable for Scots pine and richer soil suitable for the faster growing conifers, and average the whole at 60 cb. ft., we find that allowing 30 cb. ft. to the ton, about 2 tons per acre per annum can be grown.

Employment. The figure generally accepted (Schlich, Nesbit, etc.) is one man to every 100 acres during the planting stage, and one man to every 50 acres in the productive stage.

Value of the Crop. Taking the value of timber "in situ" at 6*d.* to 10*d.* per cb. ft., the annual return should be something between £1 10*s.* and £2 10*s.* per acre per annum.

Conclusion. From the above it should be easy to construct a table, from which, *caeteris paribus*, it should be possible to decide whether it was or was not in the interest of the State to take any particular sporting or grazing subject for sylvicultural purposes. Such a table would include :—

(*a*) Bulk yield.

(*b*) Value of product.

(*c*) Rent and rateable value of the land.

(*d*) The employment per acre.

(*e*) The amount of land suitable for small holdings.

(*f*) Proportion of land which could be economically afforested with average yield per acre per annum.

Calculations based on these lines should remove decisions out of the realms of personal or political fancy into the more sober realms of ascertainable fact. The nation imports both timber and mutton, it must be to the interest of the nation to grow on the land the crop which will give the most valuable product, the greatest bulk yield and the greatest amount of employment.

A general consideration of these facts and figures will show that land wholly or mainly devoted to sport is the land which in the best interests of the nation should be devoted to forestry. It must, however, not be forgotten that there are certain definite limitations which nature imposes.

Deer forests and grouse moors, for the most part, consist of high land, difficult of access, poor in quality, with a low average of plantable land. Land devoted to sport in England is often unsuitable for any other purpose, including forestry.

The surveys of deer forests are by no means complete, but it is probable that only one acre in five to six in the average deer forest is suitable for planting. (N.B.—The proportion of plantable to unplantable land, including deer forests at present acquired by the Commission is approximately 70% plantable, 30% unplantable.)

Considerable tracts of waste land will never grow trees to advantage; the exposed flat lands of Caithness and Sutherland, the Outer Islands, the unsheltered western slopes facing the Atlantic; areas over 1,000ft., except in certain cases where shelter is given by high mountains in the immediate vicinity; land at great distance from a railway or water carriage; areas where there is no resident population, and where the amount of agricultural land is too small for establishing holdings.

Forestry and Small Holdings.

Authoritative promises, frequently repeated, have been made to the soldiers who fought in the War that land would be made available for the creation of small holdings for all who wished to settle on the soil.

Promises of this nature are notoriously easy to make and equally difficult to fulfil.

When soldier settlements came to be considered in detail, it was found that while land could be secured in abundance at no unreasonable rate—considering the fall in the value of money — houses, stock and equipment had doubled, if not trebled, in price, that almost all the soldier applicants were without capital, while not a small number were without agricultural experience as well.

The sums allotted, originally considered sufficient, even generous, when voted by Parliament, were soon shown to be hopelessly inadequate to meet the situation. I believe in one country alone—Scotland—there were over 10,000 applicants. The cost of purchasing, equipping and stocking a self-contained small holding cannot be less than £2,000 to £3,000; if self-contained holdings alone are resorted to, a total of over £20,000,000 would be required for this part of Great Britain alone.

As soon as it became evident that very slow progress was being made in land settlement, that the money was not sufficient for self-contained holdings and that smaller holdings with employment in the neighbourhood would have in some measure to take their place, a Cabinet Committee was appointed to go into the question of soldiers' settlements and report on ways and means and the reason for past delays.

As a contribution towards the settlement of this most difficult question, I would suggest forestry as one of the most suitable employments for soldier land settlers.

Certainty of Employment. State forestry means working plans: that is to say, schemes of employment plotted out for many years ahead and a general policy of work laid down for the period of the rotation. It would be perfectly easy to arrange in any area for a given number of days' work per annum for a given number of men from the start of planting operations up to the time when thinning operations were begun and when the work would automatically increase and go on increasing up to the time of final felling.

Seasonable Suitability. Forestry work is mainly undertaken at a time of year when agricultural work on the allotments or small holdings is at a standstill.

Work easily learnt. Forestry work is easily learnt by men trained in field work. The habit of outdoor work and agricultural experience are of definite value. The work is conducted under supervision and a few months' instruction should give average efficiency.

No capital required. Small holdings connected with State forestry require little or no initial capital. The houses would be the property of the Forestry Service. Money for stock, agricultural implements and furniture would be all that would be required in the first instance.

Chance of Success. The small holder's position until he has gained agricultural experience is at best a precarious one. One hundred and fifty days of certain work between October and April should ensure a livelihood even if no great agricultural results were obtained in the earlier years

from the holding. A labourer with land in nine cases out of ten, is better off than a small holder with borrowed capital paying rent on an understocked holding.

If the nation is determined to implement its promise to soldiers and sailors and create small holdings on an extended scale, there would appear to be at all times a *prima facie* case for considering co-operation between those charged with soldier settlements and those responsible for State forestry.

The question of financing small holdings in connection with Forestry is difficult, but not impossible.

In the majority of estates, grazing farms or sporting subjects acquired for forestry, a certain proportion of agricultural land is usually found. This could be readily made available for soldier settlements.

The cost of equipping these holdings might be met in part by the Forestry fund, up to the extent that the fund is interested in the settlement of permanent labour in the vicinity of its forests, say, £250-£300 per settler.

Part of the cost of housing might be met from the £15,000,000 voted under the Housing (Additional Powers) Act, say, £250 per house erected.

The balance of the cost of settling soldiers in holdings would have to be met from such votes and such departments as are charged with the duty. This would, in certain cases, entail legislation.

The "overhead" charges for settlement schemes of this sort should not be heavy. The Forestry Commission either acting through the Office of Works for permanent buildings or through its own staff for temporary buildings, is at present in a position to deal with the construction which would be required.

A policy of closer settlement in connection with forestry is no new idea. In France and Germany, and, indeed, in some parts of Great Britain where larger woodlands exist, colonies of small holdings have grown up who look to the forests as their means of support.

A standing example of the growth in numbers and wealth of small holders in connection with forestry is the 1¾ million forest area of the Landes.

In little more than 100 years the Landes and Girondes Departments have grown from the poorest departments in France to the most wealthy. State forests, communal forests, peasant owned forests exist side by side. The country is practically rate free, and without poor or unemployment, and the malarious swamps are now regarded as health resorts for phthisic patients.

A small holding policy in connection with Forestry cannot be built up in a day. The number of plants in the nurseries, the rate at which planting land can be acquired, place definite limitations on progress in this direction. A start, however, might be made, but I must again repeat, the restricted nature of the block grant, all too small as it is for the programme indicated by Parliament, makes it essential that only such monies can be spent on establishing settlers as would constitute a legitimate charge on the Forestry Fund.

First Year's Work of the Forestry Commission.

The Headquarters of the Forestry Commission has been recruited and organised.

Administration by Assistant Commissioners as defined by statute, has been established in England and Wales, Scotland and Ireland. The Divisional organisation has been completed, and the district Officers have for the most part been appointed and are gradually taking over their duties. The financial branch of the department has been formed, and methods of audit, accounting and costing have been approved.

Land Acquisition and the planting of land acquired has begun. In this connection I may say that we have planted 1,500 acres in the first year and propose to plant 5,700 acres this year as against 0 and 3,300 acres laid down in the schedule of the Reconstruction Forestry Sub-Committee's Report for the 1st and 2nd years' work.

As regards land acquisition, we are ahead of schedule. 69,000 acres were acquired in the first 12 months, and in view of the amount of land at an advanced stage of negotiation we hope to be again well ahead of schedule in the 2nd year's work.

The planting schedule outlined in the Forestry Sub-Committee's Report, mounts rapidly from 13,000 acres in the 5th year, to 26,700 acres in the 9th year. If we are able to maintain our present lead of schedule figures, we shall have by the 5th year to hold upward of 200 millions seedlings and transplants instead of 129 millions that we have in the nurseries to-day.

The purchase of seed abroad direct from the Dominions or State forest services, the

organisation of the collection and extraction of seeds at home, the study of economy in nurseries, planting, fencing and preparing land have all taken up a considerable time of the Commission's staff.

Education. As already pointed out, the education of :—

(*a*) Forest officers.
(*b*) Landowners and land agents.
(*c*) Practical foresters and foremen—has received and is receiving close attention.

The following Bulletins and leaflets have been issued :—

Bulletin No. 1. "Collection of Data as to the Rate of Growth of timber."
Bulletin No. 2. "Survey of Forest Insect Conditions in the British Isles."
Bulletin No. 3. "The Rate of Growth of Conifers in the British Isles."
Leaflet No. 1. "Pine Weevils."

A bill will shortly be brought before Parliament to effect the transfer of certain forest lands administered by, and forest engagements entered into by, other Departments.

Consultative Committees for England, Scotland, Ireland and Wales have been appointed, and have given valuable assistance in the compiling of regulations for Grants and Profit-sharing schemes. They have advised on questions such as assistance to private planters, the taxation of woodlands, transport questions, and the organisation of the seed and forest transplant supply.

One of the most important matters about which we hope to get their assistance and advice is the question of how to make and keep up to date a survey of existing woodlands. Until we have a greater knowledge of our producing and non-producing woods, the rate of replanting, etc., it will be impossible to speak with authority on forest policy or form estimates of future production.

The outstanding feature of last year's work was the Imperial Forestry Conference, when, for the first time in the history of the Empire, forest representatives from every Dominion and from practically every Crown Colony met together and discussed questions of interest in the forestry world.

The Resolutions have been published in the form of a Command paper, and it is enough to say here that amongst other things that the forest officers were unanimous in insisting on :—

(1) The importance of a comprehensive survey of Imperial timber resources.
(2) The importance of a centre for higher forestry education for those parts of the Empire which have no higher forestry educational facilities of their own.
(3) The establishment of an Imperial Forestry Bureau.

Action has already been taken over 2 and 3. An Inter-Departmental Committee, with representatives from the India Office, Colonial Office and the Forestry Commission, is at the present moment considering the ways and means for the establishment of a centre for Higher Forestry Education.

The question of an Imperial Bureau is now being considered by the Treasury.

As I have already indicated, we hope in the near future to put our own house in order, and to be able to state what area of woodlands we possess, their annual yield, and rate in which they are being denuded or replanted.

DISCUSSION.

The Chairman (Col. George Loyd Courthope, M.P.), in opening the discussion, said he thought it was not generally realised what a herculean task the author and his colleagues had undertaken when they became Forestry Commissioners. Probably all those present were familiar with the recommendations of the Report of the Forestry Reconstruction Committee, over which Mr. Acland presided, but he would like to remind them that the policy of insurance recommended by that Committee required an increase of our existing woodland acreage by rather more than 60 per cent., and when, three years later, the author and his colleagues were appointed Forestry Commissioners, not only had a very large portion of the existing 3,000,000 acres of woodland been devastated for supplying the needs of the war but the money which it was proposed to place at the disposal of the Forestry Commissioners was not increased in nominal value and had very largely decreased in actual value. Therefore the task, which was a heavy one when Mr. Acland's Committee drew up its report at the end of 1916 or the beginning of 1917, had now become colossal. He congratulated the author and his colleagues very warmly and sincerely upon the careful and skilful way in which they had commenced their work. Some people said they had not gone fast enough, but personally he thought that if they had gone any faster they would have made fatal mistakes. He had had special opportunities of knowing what the Forestry Commissioners were doing, because, besides

being associated with the two Forestry bodies in England which were carefully watching the Commissioners' actions, he had been appointed under the Forestry Act as Chairman of the English Consultative Committee. That gave him the position of a kind of licensed critic, but he had found it very difficult to launch any substantial criticism against the author and his colleagues. He hoped they would long continue in their present position and that the confidence which the author's appointment inspired would be maintained throughout his whole term of office.

THE SECRETARY read the following letter from Sir William Schlich, K.C.I.E., F.R.S.:—

"Having been occupied during the last 54 years in promoting systematic economic forestry in the British Empire, it is a great disappointment to me that I shall not be able, owing to indisposition, to be present this evening when Lord Lovat will, as it were, read the first report of actual progress in forestry achieved in the United Kingdom. Having been allowed to see a proof of Lord Lovat's paper, I desire to say that it gives an admirable account of the present position of forestry in the United Kingdom. I particularly welcome what Lord Lovat says as regards the importance of private and corporate participation in the development of forestry. I have always been of opinion that every effort should be made, not only to maintain but, if possible, to increase the share of private efforts in this country as regards forestry, and this is what the new Commission is working for. No doubt, it is desirable that a certain proportion of the area under forest shohld be held by the State, and according to the approved scheme the State is to afforest the greater part of the area to be planted during the first ten years, but it is clearly laid down on pages 41-42 of the Sub-Committee's report that in the same degree as private owners and corporations are coming forward and planting, the share of the State shall be reduced. It is to be hoped that the system of Co-partnership will help to realise this desirable aim.

Another important matter is that the system of establishing small holdings in connection with afforestation is likely to increase, and not to reduce, the area under field crops, because the arable areas here in question can be brought under the plough only if the occupiers are assured permanent work during part of the year, which afforestation will provide for them.

Lord Lovat will tell the Society that the work of the Commissioners is so well advanced that the actual planting operations are one year ahead of the official programme. I am drawing attention to this as, I am informed, a communication in a well known paper accuses the Commissioners of being behind hand. Surely the least to be expected is that writers of this class should take the trouble of ascertaining the actual facts of the case before indulging in such unwarranted criticism. The preparations necessary in inaugurating such a large scheme as that of replanting and afforesting an area of 250,000 acres at the rate of 25,000 acres a year, are far greater than a good many people imagine. They include the acquisition of the land by purchase or lease, the laying out of tens of acres of nurseries, the raising of many millions of plants, the organisation of a competent staff to design and supervise these works, to secure and train a small army of workmen—all matters which demand much forethought and time, if the operations are to be successful. Considering the very substantial progress made by the Commissioners, they deserve not criticism, but thanks for having devoted themselves with such energy to the task undertaken by them.

I further notice with satisfaction a reference to the Imperial Forest Conference held in July last. If the Commissioners had done nothing else during the first year of their activity, beyond having made the conference a success, they would have deserved well of the Empire. That conference has done an immense amount of good. I noticed that the members who attended it, have taken away with them on returning to their particular part of the Empire, the conviction that the two most important requirements to successful forest conservancy are

(1) The necessity of managing forests on the principle of a *sustained yield*; in other words, not to cut more every year than is replaced by fresh growth each year; and

(2) That each part of the Empire must secure a competent and well-instructed staff to carry out that policy.

These two points secured, all the rest will follow as a natural consequence."

SIR CLAUDE HAMILTON ARCHER HILL, K.C.S.I., C.I.E., said he had no claim whatever to expert knowledge in regard to forestry, but there were two reasons for his interest in the paper and in forestry generally. The first was that he was a member of the Empire Forestry Conference that had recently been held, and that gave him an opportunity of endorsing the Chairman's commendation of the Forestry Commission's work. He had heard many members of the Conference express surprise and gratification at the rapidity with which, once England had been awakened to the need for laying down a forest policy, she had grappled with the subject, passed the necessary legislation, and selected the best possible Chairman for the Forestry Commission. The overseas members of the Conference were very greatly impressed by the businesslike way in which the subject was being tackled, and felt that a real step had been taken towards placing Great Britain's forestry

upon a satisfactory footing and centralising at the heart of the Empire the interest in forestry, with a view to its diffusion throughout the Empire by means of co-ordinating forestry information at the centre of the Empire and imparting the highest possible education in forestry, which until quite recently it had been impossible to obtain in England alone. The second reason for his interest in the paper was to be found in that portion of it in which the author wisely anticipated future criticism of the Forestry Commission's policy, and foresaw that a time would come when people would ask why land should be taken up for forestry when it would be much better utilised for sheep farming or some other alternative. If and when that criticism arose, it would be an advantage if the Forestry Commission could be reinforced by an informed public opinion. For the purpose of informing the public regarding forestry, one of the resolutions of the Empire Forestry Conference was a recommendation for the formation of an Empire Forestry Association of an entirely non-official character. He was afraid a good deal of time had elapsed since that recommendation was made, but the Conference commended it to an *ad interim* Committee for consideration, hoping that early steps would be taken for the formation of such an Association. It was a difficult matter to launch an Empire Forestry Association really worthy of furthering the objects it should have in view, but the *ad interim* Committee had got to work and had made substantial progress towards the formation of an Empire Forestry Association, which the delegates to the Conference from overseas were so anxious to see as a co-ordinating centre for non-official opinion, appealing not only to the forestry services, but also to the commercial agencies throughout the Empire that were interested in timber exploitation. It was hoped that that Association would eventually assist the nation enormously in understanding the value of a considered and continuous forestry policy, and, if it received the support of all who were interested in the important national question of forestry, it might be of assistance to the Forestry Commission in furthering the objects which the Commissioners had in view, and which they had done so much already to secure.

MR. M. C. DUCHESNE (Hon. Secretary and Treasurer, English Forestry Association,) said that in regard to the encouragement of private enterprise in forestry, on which the author laid so much stress, the chief difficulty was the uncertainty of the market for the timber grown by private enterprise. On one occasion he heard Lord Selborne say, in referring to the terrible experiences of forestry and agriculture, particularly during the eighties, that those experiences had hung like a pall on all development in this country for the last forty years. If the forestry Commissioners wanted to encourage private enterprise in the planting of woods, they should do all they possibly could to remove that pall, and convince the landowners of this country that those experiences would not be repeated and that they need not fear the importation of cheap foreign timber. He wished to emphasise the importance of creating timber reserves as an insurance against a future emergency, and he thought that insurance should be extended to the provision of proper markets for the timber when grown. The most important way of doing that was by the education of the towns, and particularly of the timber consumers. He hoped Lord Lovat would very seriously consider the holding in the near future of a conference of timber consumers, so that steps could be taken to see how far markets could be assured and the handicaps removed under which native timber suffered to-day. Another point he wished to touch on was the alteration in the position of forestry, particularly in relation to private enterprise, brought about by the War. Private enterprise in the past had created reserves of timber on the national tradition of oak for the British Navy, but he did not think anyone would now advocate that, and private enterprise must now devote itself rather to the production of the quicker growing conifers, and particularly such timbers as the poplar. The poplar gave a very quick return and was suitable for growing in odd spinneys and even in the hedgerows. There were certain varieties of coppice which were also suitable for production by private enterprise, particularly the Spanish chestnut, which had recently been sold in the South of England for £59 and even as much as £93 an acre. As showing the necessity for ensuring proper markets for the timber when grown, he might mention that, in the case of coppice, in one area very poor prices had been obtained, simply because there was no industry in the neighbourhood to consume it, while in another district the same kind of coppice fetched more than double the price because there was an industry there which required it. He would like the Commissioners to consider also how far they could help to remove other handicaps from which private enterprise in forestry suffered, especially in the way of taxation. A very important point which he knew the Forestry Commission fully appreciated and on which it was issuing bulletins at the present time was the prevention of losses through want of knowledge and experience when planting. The unfortunate losses that had been experienced in the past emphasised the great importance of research in many directions. He wished, in conclusion, to congratulate the author and his colleagues on the progress they had already made, and hoped that their efforts would meet with success in the future.

COLONEL G. R. LANE-FOX, M.P., wished to thank the author and his colleagues very much for the splendid work thay had already done, more particularly because they were developing it so much on the lines of encouraging private enterprise. Speaking as a landowner, who had no expert knowledge of forestry, he suggested that it would be a very great advantage to other landowners besides himself if they were given an opportunity to go through a short course of education in the subject of forestry. He had had the advantage of a visit from the divisional officer in the North of England, who was very helpful and useful, but he thought that gentleman had far too large an area to administer properly, and certainly required assistance. He would like to ask the author if there was any chance of the personnel being increased or the staff being made rather more capable of covering the work they would have to do. He would also like the author to say what was the prospect of dealing with the great areas all over England and Scotland which were now felled, in the case of owners who were not in a position to re-plant. Personally, he had only felled in moderation and had tried not to let his felling go beyond his capability to re-plant, but that was rather a counsel of perfection, and in view of the increased cost of planting he was already rather appalled by the areas that required re-planting. It would be a source of satisfaction to a great many people to know what was the plan of the Commission in that respect.

SIR THOMAS MIDDLETON, K.B.E., said that, as one who has been interested primarily in agriculture, he hoped agriculturists would not criticise the Forestry Commission on the ground that it was taking land from sheep for forestry purposes. He thought the author had rather overestimated the damage likely to be done to the meat supplies of the country. Personally, he did not anticipate that .1 per cent. of the total meat supplies could possibly be endangered by any forestry policy which the author now had in view. He thought .4 per cent. would be about 7,600 tons. He had recently been looking into the question, and he believed the probable production of the 15,000,000 acres of waste grazing land in this country would be between 30,000 and 40,000 tons altogether—probably about 32,000 or 34,000 tons. That represented about six day's supply of beef and mutton for this country before the War, and about twelve days' supply during the War. The total damage that forestry was likely to do to the meat supply of this country was negligible. On the other hand, he had always anticipated that the advantages which planting out would confer on the sheep farmer by providing shelter and general improvement of the land would probably result in quite as large a production of mutton after the 1,770,000 acres were planted as there was at the present time. The author had brought out the points which appealed specially to him—and he hoped would appeal to the whole public—as the directions in which forestry was of national interest. First of all there was the great value of forestry as an auxiliary to agriculture. It was really a development of agriculture. It was impossible to get the hill lands of this country properly farmed unless they were properly afforested. Again, forestry would provide employment for a large number of men, and that would mean a much greater rural population. Those who came from the highlands of Scotland were all, he thought, anxious to see in those districts a larger population than existed there at the present time. The special appeal, however, that forestry made to him after the outbreak of war was from the point of view of insurance and national defence. Forestry provided an ideal commodity for storing. Timber at the present time took up about 11 to 13 per cent. of our total shipping, and, if matters could be so arranged as to make this country self-supporting in timber for a period of two or three years, 10 per cent. of the shipping of the country could be immediately released on the outbreak of war or in any emergency, and that would be of the greatest possible value. He was not quite so sanguine as the author with regard to the prospects of private planting. Private planting went on very slowly before the War, with compound interest at 3 per cent., and now compound interest at 5 per cent. or more had to be faced, planting became a very difficult matter for the private landowner. Personally, he was more afraid of that 5 per cent. compound interest than he was of the importation of foreign timber, and he thought it was a question that the State would have to face. It might have to be prepared to shoulder a bigger problem than Mr. Acland's Committee stated. The sum of £3,500,000 with which the Commission had been provided was a very modest one compared with the large amounts that were being expended on other objects at the present time, and he thought the clothing of the barren hillsides of this country would form quite as good an investment for the taxpayer of the present day as any of those other objects.

PROF. R. S. TROUP, C.I.E. (Professor of Forestry, University of Oxford), said that the question of the 5 per cent compound interest which Sir Thomas Middleton had mentioned was a very serious matter indeed when one was asked to answer the question as to whether forestry would pay. There were two points of outstanding importance. The first was the necessity of maintaining a sufficient supply of timber to stave off any danger such as we had experienced during the past few years in the event of war, and the second was the question

of small holdings, which he thought everyone would agree were to play a very important part in the forest policy of the future. With reference to the 5 per cent., all the foresters present would know that there was such a thing as a financial rotation in forestry, that was to say, there was a certain period in the life of a forest crop when the maximum net profit derivable from the forest was obtained. If one fell, say, ten years short of that rotation or ten years beyond that rotation, one might convert a profit into a loss. When the owners of forests were working, as they were now, with a very small margin of profit, in view of the high cost of labour and the 5 per cent. compound interest, then, in order to give an affirmative answer to the question whether forestry would pay, they must be very careful in working out their rotation with such data as they possessed. Unfortunately, as the author had said, the data possessed at present in regard to the rate of growth and volume production of various crops were somewhat deficient, but it was very satisfactory to note that the Forestry Commission had realised the importance of that particular work and had gone ahead with it in a most energetic way. It was necessary to emphasise that particular aspect of the Forestry Commission's activities, because the Commission would almost certainly be judged, at any rate during the next two or three years, by the area planted, and unless one was more or less a technical expert one did not quite see the force of enquiring into the rate of growth of trees and how much it bore on the financial question. The author had referred to the way in which private owners had carried out the work of planting and what an excellent standby it had been to this country during the war, and had said that the Forestry Commission proposed to do all it could to encourage private owners to plant in the future. There might be a danger, however, that the importance of State forestry would not be fully appreciated by the British public. Therefore one of the chief duties before those interested in forestry in this country was to try to educate popular opinion to recognise the importance of State forestry, and he agreed with Sir Thomas Middleton that the State might have to take in hand a bigger task than they had set out to undertake at present. He hoped that the area to be planted that was laid down by the Reconstruction Sub-Committee would not be final, but that it would be revised from time to time as future developments and future experience might dictate. He joined with the previous speakers in thanking the author for his most lucid and instructive paper.

Mr. G. K. Menzies said that as Secretary of the Society he would like to remind the audience of what the Society of Arts had done in the past for the encouragement of sylviculture. Mr. Duchesne had referred to the fact that from time to time there had been an outcry throughout the country as to the shortage of timber, especially for the purpose of building vessels for the Navy. That outcry was particularly loud in the middle of the eighteenth century, at the time when the Society was founded, and in 1758, when it was two years old, it took up the matter and offered in the first instance a gold medal for the largest area that was planted with oaks in the following year. The first gold medal was awarded to the Duke of Beaufort, who planted some 20 acres with oaks, and during the next sixty to seventy years such offers were continually renewed by the Society, with the result that well over 50,000,000 trees were planted throughout the country, and a great many of the present woods owed their existence to the initiative of the Society of Arts.

Major-General The Right Hon. Lord Lovat, in reply, said he knew that all the members of the Forestry Commission associated themselves wholeheartedly with the remarks that were made by Sir Claude Hill on the importance of an Empire Forestry Association. Such an Association, purely non-official in character, undoubtedly would have an important part to play not only in educating the people of this country in the real value of the growing of timber, but also in doing the same work abroad. He did not think that point could be better put than it was by an Australian representative at the Forestry Conference, who said: "What we want to teach our people in Australia is that it is not good policy to make one blade of grass grow where two trees grew before." That really summed up the situation in regard to the education that was required not only in this country but in many other parts of the Empire. Then again, an Empire Forestry Association could be a real institution for promoting the status and welfare of the forest officers. The British Empire possessed very nearly half the accessible trees of the world, and yet its forestry officials probably formed only one-hundredth of the forestry officials of the world. The British Empire was not anything like developing its forestry resources; in fact, it had not even got an accurate knowledge of how great those resources were. An Empire Forestry Association, by linking up the forest officers' interests and by helping education, could undoubtedly do most admirable work, and he wished Sir Claude Hill success in his efforts to form such an Association. He agreed with Mr. Duchesne as to the importance of providing markets for the timber. To induce the private owner to plant, the Forestry Commission had first of all to face the initial cost, then it had to tackle the question of taxation, then it had to deal with the question of transport of the timber, a most important point at the present time owing to the high railway rates—and finally it had to discuss the question of markets. The

Commission had not lost sight of that last point, but it was only a year old and had a great deal of work before it. With regard to Col. Lane-Fox's question about a short course of education in forestry for landowners, the Commission had as yet organised only one such course, but it had proved such a success that it was intended to make those courses a feature of some of the schools as soon as possible. It was obviously in the interests of the nation that the errors made by landowners in planting should be reduced to a minimum. With regard to the divisional officer in Yorkshire, the Commissioners hoped in time, when their district officers were engaged and fully trained, to divide up the country further and to have district organisation as well as divisional organisation. It might be from two to four years before the whole of the district officers had sufficient practical experience for that to be brought about. For the time being the divisional officers would have to do a great deal of the advisory work. In France there were conservators with inspectors under them, and it was hoped to have the same kind of organisation in this country, which would of course, increase the number of men available and make them more readily accessible. The question of storing timber as an insurance for a time of war was a most important one. He agreed with Sir Thomas Middleton that timber took up 13 per cent. of the total shipping. It was definitely proved by the Acland Committee that during the worst period of food shortage in this country the amount of shipping which had to be used for timber steadily rose. If that was only realised by the politicians and by the general public, undoubtedly the question of insurance in timber would be given greater attention than it was at the present time. With regard to the question of private planting, Prof. Troup and Sir Thomas Middleton expressed a doubt as to whether that would be done on the scale that the Forestry Commission hoped. Personally he was rather doubtful as to whether individuals would come forward and plant to the extent that was desired, but he believed that in the past the rotation of the average private forest was a great deal longer than most people anticipated. He believed that in recent times not more than about 16,000 to 25,000 acres were planted a year by private landowners. He thought, however, there would always be a certain number of proprietors who would plant from public spirit or with the idea of insurance against death duties or for the continuance of property in the hands of their successors. With reference to the desirability of obtaining definite knowledge as to the extent of the woodlands in this country and their yields, the Commission hoped that the Consultative Committees in England, Scotland, Ireland and Wales would help in that matter, and also the various sylvicultural bodies. General interest could not be aroused nor the whole forestry situation properly settled until it could be definitely said how many acres of productive woodlands there were in this country, and he was satisfied that when that figure was arrived at, nine people out of ten would be very much surprised that it was so small. The Commission would be able to publish that figure, and he thought that private forestry and State forestry would then secure the provision of that area of woodland, which, after very long and serious enquiry, Mr. Acland satisfied himself was necessary to tide this country over a period of a three-year war, namely, 5,000,000 acres.

On the motion of the Chairman, a hearty vote of thanks was accorded to Lord Lovat for his interesting and valuable paper, and the meeting terminated.

Dr. A. H. Unwin writes:—

Having heard Lord Lovat's brilliant summary on the past and present position of Afforestation and the Forestry Commission's activities during their first year, I think a strong case is to be made out for an acceleration of the Afforestation programme for this country. Perhaps it would be of interest to quote a few figures which I gave in a pamphlet entitled "Labour and Afforestation."* Out of 3,000,000 acres of forest land in Great Britain, only 60,000 or 2 per cent. belong to the State; the rest is private property. The average timber import requirements of the country amount to 240,000,000 cubic feet of timber, which is the same as the annual increment of growth of all the trees standing on an area of 4,000,000 acres. On the average the timber imports are valued at £37,000,000 per year.

Under the Forestry Commission's auspices, it is proposed to plant up 1,180,000 acres during the next 40 years, partly by Government agencies and partly by private owners. This area, together with proper production from the replanting and care of the existing 3,000,000 acres, would eventually yield nearly as much timber as our pre-war requirements. However, Great Britain's requirements are increasing at the rate of certainly 5,000,000 cubic feet per annum, looking forward over a period of 70 years. Thus the annual requirements of the country 70 years hence will probably be 988,000,000 cubic feet. From this should be deducted roughly, 141,000,000 cubic feet of hard woods such as mahogany, teak, etc., which it is not possible or profitable to grow in this country. There remains thus an import of about 847,000,000 cubic feet which will be required. Taking an average production of 5,000 cubic feet per acre, the net import quantity could be produced from an area of 11,758,000 acres on a 70 years' rotation.

* "Labour and Afforestation." Published by the Labour Party, 33 Eccleston Square, London, S.W.1.

In Great Britain there are 12,300,000 acres of uncultivated land below an altitude of 1,500 feet. This altitude is about the maximum for profitable planting at present. Thus, if the necessity arises it is possible to plant up 10,000,000 acres instead of only 1,000,000. Then, too, under the Forestry Commission's plan, it is estimated that only 125,000 people would eventually be settled on the land, whereas under an accelerated scheme of planting 10,000,000 acres there would be more than 6½ million people settled on the land or connected with the forest industries arising from the big afforestation programme. The afforestation period could either be 20 or 30 years, or, if the necessity did not arise, it could be spread over a period of 70 years.

So far the Forestry Commission have been given a Block grant of rather more than £3,000,000 to cover the cost of ten years' work. Under the accelerated programme of planting at the rate of 332,000 acres per year, the cost of planting at £10 per acre would amount to £3,332,000 per annum. For the provision of the full amount of staff, seeds, tools, manures, the cost might reach £700,000 per annum. Allowing the annual cost of acquiring land or assisting private owners to the extent of £10 per acre in planting, the annual cost would amount to £3,320,000. Thus, the total annual average expenditure would amount to £7,340,000 and last for a period of about 30 years. After this period a larger income would be received which would go on increasing until it culminated 40 years later. In the past the value of timber has risen at an annual rate (with fluctuations) at the rate of 3 per cent per annum. Thus, if we take the average value of standing timber now at a 1*s*. per cubic foot, at the end of the 70 year period the probable value will be 3*s*. Assuming now an annual production of only 5,000 cubic feet per acre, we have a total production of 714,285,000 cubic feet per annum. And taking now the total quantity of mature and immature timber standing on the 10,000,000 acres at the end of the 70 year period, we have a total value of £7,500,000,000, which is about the same as the present national debt. Thus, it will be seen, with an accelerated Afforestation scheme, it is possible to find work for nearly six and a half million people and create a final timber value of £7,500,000,000.

THE GENISTA INDUSTRY.

In various parts of Italy the genista grows in profusion, but up to the present, no considerable exploitation has taken place. The following information on the available supplies, and on the use made of the plant in the country, is taken from the *Board of Trade Journal*.

At Florence the plant is regarded as a ubiquitous weed, and is not cultivated for any purpose in Tuscany. The peasants use it for making rough baskets, but it has no commercial value in that part of Italy.

It grows very extensively on the slopes of Monte Somma and Monte Vesuvio. The leaf gives a very good fibre resembling hemp. It has, however, only been experimented with, and has never been commercially developed. On the other hand, *agave siciliana* is found growing in great quantities along the railways in Sicily, especially in the Provinces of Trapani and Palermo, and in some parts of Calabria, and if the leaf is properly treated by modern machinery it gives an excellent fibre which is used for small ropes. It resembles manila and is very strong, and could easily be cultivated in localities near the sea.

At Palermo two societies have been formed recently with a capital of 100,000 lira and 60,000 lira respectively, for development purposes. In the case of one, the land on which the plant grows is owned by the shareholders, who intend starting operations this year. They have, so far, not erected any machinery, but it is understood that they intend doing so as soon as possible.

Samples of the genista fibre grown in Mormannó may be seen by British firms interested on application to the Department of Overseas Trade, 35, Old Queen Street, Westminster, S.W. 1. The samples include unbleached fibre, half-bleached, and finished fibre of the finest quality.

KAURI OIL WORKS IN NEW ZEALAND.

The first plant in New Zealand for the extraction of oil from kauri-gum peat, or "pukau" (which is part of the soil of the buried kauri forest saturated with the oil of the kauri), commenced operations at Redhill (North Auckland) last December. According to a report by the U.S. Vice-Consul at Auckland, the plant is built to turn out 4,500 gallons of oil per week, its fractions being motor spirit, a valuable solvent oil, a turpentine substitute, and paint and varnish oils. The process of extracting the oil is very similar to distilling oil from shale. The cost of distillation is about the same, but the digging of the pukau from the swamp is infinitely cheaper than working a shale deposit, as pukau generally runs in layers four feet thick, having only one foot of overearth.

At present pukau is sieved by hand; the small pieces of gum (known as nuts, chips, and seed gum) are saved and oil is extracted from the residue. A new machine is being installed for sieving the pukau and washing the gum, thus saving a great amount of labour. This will be a subsidiary branch of the oil works.

In the swamps large quantities of oil soaked timber are found, which later will likewise be treated for oil. It is claimed that the bark, limbs, and roots of the kauri tree are capable

of yielding 110 gallons per ton, richer than the pukau itself, and it is estimated that the best swamps carry 500 tons of this oil soaked timber.

The supporters of this Redhill plant claim that the extracting of oil from pukau will become the most important industry in New Zealand, since there are thousands of acres of this swamp land in the North Auckland Province, and each acre contains a large quantity of oil.

SHARK FISHING IN LOWER CALIFORNIA.

The shark fishing industry is becoming increasingly important in the Ensenada consular district. The Lower California shark, known locally as the dogfish shark, is from four to five feet long, and weighs from 90 to 125 pounds. The fishing is usually done by individual fishermen working out from camps on land. The fish are caught on long set lines, on which are 50 to 100 hooks baited with small fish or lumps of shark meat. These lines are secured to floats, and the fisherman visits the lines daily to remove the catch.

The fins, according to the American Consul in Ensenada, Lower California, are sold for consumption by Chinese in shark-fin soup. The liver is boiled down, and shark oil rendered out; each liver gives an average of 1 gallon of oil. This oil is used in paints and as a leather preservative. The remainder of the fish is dried and made into fertilizer or chicken feed. The skins are not utilized, except for fertilizer. Frequently shark steaks are sold by Chinese in the district under the name of grayfish.

The large canneries operating fish-fertilizer plants in San Diego, California, are eager to buy shark, and the newly finished plant at Sauzal, Lower California, expects to specialize on converting shark unto fish-meal fertilizer. Whereas formerly sharks caught in nets were separated out from the more valuable fish and returned to the water, they are now brought ashore, although the demand is not yet sufficient to warrant using nets for shark exclusively.

CORRESPONDENCE.

A CANADIAN AIR SERVICE.

When Professor Frecheville read his paper on "The Mineral Resources of the British Empire," on the 6th February, 1918, he made certain definite statements as to extensive copper deposits in the Arctic regions of Canada, and expressed the opinion: "In view of what is taking place around us, it does not require much, if any, expansion of what has already been done to allow aeroplanes to be considered as a possible help, particularly in view of the fact that numerous lakes in that region would appear to facilitate the establishment of landing and supply stations."

In my written remarks on the paper, I stated, *inter alia*: "Mr. Frecheville said that the aeroplane might solve some difficult transport questions, as he passed his pointer over the map of Canada, where, he said, deposits of copper ores exist. This is no fantastic suggestion. The progress of aeronautics during the war is convincing evidence that the future will see wonderful developments in this direction, but Mr. Frecheville lost a point to emphasise an argument when he failed to mention that in the intervening space traversed by his pointer there are large areas impregnated with desiccated petroleum, which some authorities believe will yet prove a mask to the presence of valuable deposits of petroleum, and should this be realised, Mr. Frecheville's aerial transport rider would probably find supplies en route, and possibly a source of wealth infinitely greater than the original object of flight."

My object in recalling these statements is to draw attention to the following extract from a daily paper:—"An air route to the new oil Dorado of the Mackenzie River region will be established shortly. Sites for aerodromes have been secured on the Peace River, which will be the southern terminal."

A more rapid realisation of advanced ideas is difficult to imagine, and Canada is to be congratulated on the discovery of oil, and the enterprise in establishing an aerial line to assist in its development.

HUGH PEARSON.

GENERAL NOTES.

THE AFRICAN OIL PALM.—The well-known palm oil and palm kernels of commerce are both obtained from the fruit of the African oil palm. The oil occurs in the fleshy pulp which surrounds the nuts. Both materials are at present produced from trees growing wild in the forests of West Africa, and largely in British West Africa, where the industry is a most important one. Large quantities of palm oil are used as food in West Africa, and, in addition, many thousands of tons are sent annually to the United Kingdom and other countries where the oil is used for making soap and candles, and, to some extent, for the preparation of edible fats. There is also a large export trade in palm kernals, the oil of which is largely employed in the margarine industry. The valuable nature of these products obtained from the wild oil palm in West Africa has led to trials being made elsewhere in the cultivation of the palms in properly kept plantations. Success has been already obtained on such plantations in Sumatra and Malaya, where the palm grows well, and it is probable that in the Eastern tropics the African oil palm will become

a plantation crop of great importance. An article on the African oil palm, dealing with all aspects of the subject, appears in the current number of the Bulletin of the Imperial Institute (London, John Murray, price 3s. 6d.). It is shown in this article that an oil palm plantation may generally be expected to yield larger profits than those obtainable from coconuts.

IMPORTS OF MOTOR CARS INTO INDIA.—It appears that 1,041 motor cars were imported into British India during September, 1920, and of these, 723 were consigned from the United States, and 287 from the United Kingdom. During the six months, April to September, 1920, the number of motor cars imported was 7,498, as against 2,553 in the corresponding period of the previous year. The United States recorded 5,654, the United Kingdom 1,902, Canada 542, France 49, and Italy 43. Bombay imported 2,775 cars, Bengal 2,694, Madras 908, Sind 590, and Burma 531.

INDIA AND INTERIMPERIAL TRADE.—His Majesty's Trade Commissionerships were created primarily to foster the trade of the Home Country, and they seem to be performing that object with no little success. A recent communiqué issued in India, states that by arrangement with the Board of Trade, the Commissioners in the Dominions and Colonies correspond with the Director General of Commercial Intelligence in Indian traders' interests, report to him openings for Indian exports, and reply to local inquiries for Indian goods. Such correspondence, it is added, has stimulated the Indian export trade and has been the means of introducing a large number of Indian firms to importing houses in the Dominions and Colonies.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced) :—

JANUARY 12.—(Aldred Lecture). CHARLES S. MYERS, M.D., Sc.D., F.R.S., Director of the Psychological Laboratory, and Lecturer in Experimental Psychology, University of Cambridge, "Industrial Fatigue." W. L. HICHENS (Chairman, Messrs. Cammell, Laird and Co., Ltd.) in the Chair.

JANUARY 19.—F. M. LAWSON, Assoc. M.Inst.C.E., "The Future of Industrial Management."

JANUARY 26, at 4.30 p.m.—A. ABBOTT (Department of Scientific and Industrial Research), "The Origin and Development of the Research Associations Established by the Department." W. GREENWOOD, M.P., Vice-President, British Cotton Industry Research Association, in the Chair.

FEBRUARY 2.—A. F. BAILIE, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World." PROFESSOR SIR JOHN CADMAN, K.C.M.G., D.Sc., in the Chair.

FEBRUARY 9.—WILLIAM ROTHENSTEIN, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England."

FEBRUARY 16.—WILLIAM CRAMP, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice."

FEBRUARY 23, at 4.30 p.m.—SIR DANIEL HALL, K.C.B., F.R.S., Permanent Secretary, Board of Agriculture, "The Present Position of Research in Agriculture." (Trueman Wood Lecture.) Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the Chair.

INDIAN SECTION.

Fridays at 4.30 p.m.

JANUARY 21.—R. S. TROUP, M.A., C.I.E., Indian Forest Service, Professor of Forestry at the University of Oxford, "Indian Timbers." SIR CLAUDE H. A. HILL, K.C.S.I., C.I.E., in the Chair.

FEBRUARY 18.—Paper to be announced later.

APRIL 22.—Sir George Birdwood Memorial Lecture.

MAY 27.—WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

COLONIAL SECTION.

TUESDAY, FEBRUARY 1, at 4.30 p.m.—G. C. CREELMAN, LL.D., B.S.A., Agent-General for Ontario, formerly Commissioner of Agriculture and President, Ontario Agricultural College, "Modern Agriculture."

INDIAN AND COLONIAL SECTIONS.

(Joint Meetings.)

At 4.30 p.m.

FRIDAY, MARCH 4.—WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

TUESDAY, MAY 3.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

HOWARD LECTURES.

ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E., "Aero Engines." Three Lectures. January 17, 24, 31.

Syllabus.

LECTURE I.—Early Attempts to Produce Motive Power for Flight—External and Internal Combustion Methods—Possible Fuels—Materials of Construction—Steam, Reciprocating and Turbine Engines and Internal Combustion Engines—Development as regards Thermal Efficiency, Power and Weight—Thermodynamic Cycles in Internal Combustion Engines—First successful Engines in Flight—Aero Engines in 1910—Development before 1914—Relative Importance of Weight and Fuel Economy.

LECTURE II.—British and German Aero Engines at the beginning of the War—Development of the six main types during the War—Comparison of British and German Practice—Special Experimental Types—Limiting Conditions in Different Types—Supercharging—Examples of Different Types.

LECTURE III.—Engines in use after the War—Comparative Tables of Piston Speeds, Mean Pressures, etc. — Conditions Governing and Limiting Further Progress—Variations of Thermodynamic Cycles—Regeneration—Possible Progress as regards Materials—Future Development of Aeroplane and Airship Engines.

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures, February 14, 21 and 28.

MAJOR G. W. C. KAYE, D Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.C., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

MEETINGS FOR THE ENSUING WEEK*

MONDAY, JANUARY 10.. Royal Society of Edinburgh. 22, George Street, Edinburgh, 4.30 p.m. 1. Mr. F. Unwin, "The Transverse Galvanomagnetic and Thermomagnetic Effects in Several Metals." 2. Mr. A. R. Horne, "A Graphical Method of Determining Sheer Influence Lines, and Diagrams of Maximum Shearing Force, for a Beam subjected to a series of Concentrated Rolling Loads."

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m. Mr. W. W. Jenkinson, "The Streets of London before the Great Fire."

Geographical Society, 135, New Bond Street, W., 8.30 p.m. Capt. J. B L. Noel, "A Reconnaissance in Persia North of the Elburz."

TUESDAY, JANUARY 11.. Institution of Automobile Engineers (Graduates' Meeting) 7, The Quadrant, Coventry, 7.45 p.m. Mr. J. Newey, "Cooling Systems."

Manchester Geological and Mining Society (Manchester), 4.30 p.m. Mr. W. D. Hobson, "Slate Quarrying in North Wales."

Institute of Metals (Imperial Hotel, Temple Street, Birmingham), 7.30 p.m. Mr. E. A. Smith, "Segregation in Non-ferrous Alloys." (39, Elmbank Crescent, Glasgow), 8 p.m. Mr. S. E. Flack, "Rolling and Extrusion."

Civil Engineers, Institute of, Great George Street, S.W., 5.30 p.m.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Prof. C. G. Seligman, "The Older Palaeolithic Age in Egypt."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Sir Henry Birchenough, "Cotton Growing within the Empire."

Horticultural Society, Vincent Square, Westminster, S.W., 3 p.m.

WEDNESDAY, JANUARY 12.. Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Capt. S. Bramley-Moore, "Recent Developments in Transmission."

United Service Institution, Whitehall, S.W., 5.30 p.m. Wing-Commander J. A. Chamier, "The Use of the Air Force for Replacing Military Garrisons."

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Mr. S. G. Kanhere, "Ramayan, the Great Sanskrit Epic."

THURSDAY, JANUARY 13.. Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m., Miss Hilda C. Bowser, "The Buddhist Temples of Korea."

Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m.

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W.1), 6 p.m., Sir W. H Bragg, "Electrons" (Kelvin Lecture).

Historical Society, 22, Russell Square, W.C., 5 p.m., Miss M. L. Bazeley, "The Extent of the English Forest in the 13th Century."

Mathematical Society, Burlington House, W., 5.30 p.m.

Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m., Mr. H. Kempton Dyson, "Tests on High Tensile Steels."

FRIDAY, JANUARY 14.. London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m., Mr. C. Clark, "Dickens' London."

North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Westgate Road, Newcastle-on-Tyne, 7.30 p.m., Sir James Kemnal, "Advantages of Water-tube Boilers in Merchant Ships."

Art Workers' Guild, 6, Queen's Square, W.C., 8 p.m.

Astronomical Society, Burlington House, 5 p.m.

*For Meetings of the Royal Society of Arts see page 99.

OFFER OF A SET OF JOURNALS.—A complete set of unbound *Journals* for the last twenty years has been placed at the disposal of the Secretary of the Society for presentation to a public library or institution which will undertake to bind and preserve them. Applications should be addressed to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2

Journal of the Royal Society of Arts.

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FRIDAY, JANUARY 14, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 17TH, at 8 p.m. (Howard Lecture). ALAN E. L. CHORLTON, C.B.E., M. Inst. C.E., M.I.Mech.E., "Aero Engines." (Lecture I.)

WEDNESDAY, JANUARY 19th, at 8 p.m. (Ordinary Meeting.) F. M. LAWSON, Assoc. M.Inst.C.E., "The Future of Industrial Management." THE RIGHT HON. LORD ASKWITH, K.C.B., K.C., D.C.L., in the Chair.

FRIDAY, JANUARY 21st, at 4.30 p.m. (Indian Section.) R. S. TROUP, M.A., C.I.E., Indian Forest Service, Professor of Forestry, University of Oxford, "Indian Timbers." SIR CLAUDE H. A. HILL, K.C.S.I., C.I.E., in the Chair.

Further particulars of the Society's meetings will be found at the end of this number.

EXAMINATIONS, 1921.

The first examination this year will commence on March 14th and the last day for receiving entries is Monday, February 14th. The second examination will commence on May 2nd and the last day for receiving entries is Monday, April 4th.

Forms for application for examination papers will be posted to all centres on the 24th inst.

In the County of London the elementary stage only will be taken in March, but in May examinations will be held in all three stages.

JUVENILE LECTURE.

On Thursday afternoon, January 6th, Sir Frederick Bridge, C.V.O., M.A., Mus. Doc., Emeritus Organist, Westminster Abbey, delivered the Juvenile Lecture on "The Cries of London, which children heard in Shakespeare's time." Sir Frederick was ably assisted in the rendering of the various musical selections illustrating the lecture by Mr. E. Stanley Roper, Mr. Graham Smart, Miss Champneys and Miss Peachey. The songs were taken from "The Cries of London," and included works by Weelkes, Orlando Gibbons, John Cobb, and Richard Deering.

Sir Frederick said in Shakespeare's time the streets of London rang with music all day and part of every night, and he thought it was a pity we did not hear such tunes at the present time. The children in those days were awakened by the cries of the vendors of fish, fruit and vegetables, and other commodities, sung to quaint musical tunes. They should remember that Shakespeare lived in the reign of the great Queen Elizabeth, an excellent musician, who first sanctioned the use of hymns in the Church service. The words of the cries of London, he said, had been familiar to literary people for a long while, but it was a curious fact, that with one slight exception, none of the tunes of the old cries had been reproduced. The words had been preserved in an old poem, "London Lickpenny," or "Lackpenny," written by an unfortunate monk who came up to London in the 15th century. This gave the words but not the music. By a fortunate chance, however, three of the greatest musicians contemporary with Shakespeare seemed to have struck upon the idea of making use of these delightful songs, and they each of them wrote a piece much in the same style.

Weelks's "Humorous Fancy," which was then sung, gave a tuneful rendering of the cries of vendors of fish, pies, fresh vegetables, kitchen stuff, milk, salt, brooms, and of the chimney sweep and tinker. The next piece by Orlando Gibbons, was particularly interesting, because it gave us a good idea of what Old London was like from daybreak. Gibbons started with the Cry of the Watchman "God give you

good-morrow, my masters! Past three o'clock and a fair morning!'' followed by the cries of the vendors of various articles, the corn-cutter, and the town crier announcing the loss of a grey mare on the 30th of February. Sir Frederick said he had discovered that Gibbons, in his ''In Nomine,'' had introduced an ecclesiastical melody—an old hymn tune—which was played by one of the instruments right through the piece. He did not think it was done from any irreligious motive, but very possibly to represent that while all the busy life was going on in London, some old monk was at the same time walking along the streets humming a religious melody. Sir Frederick also mentioned that Cobb in ''The Cryes of London Town,'' had worked in one of the well-known present day Westminster Chimes, which was evidently put in on purpose, and that this was the first time he had met with the tune.

Selections from Deering's "Fancy," were then given, including the cries of the Apprentices in the different shops; the blacking man; the cooper (which Sir Frederick said was the identical tune frequently mentioned by Shakespeare), the buyer of coney and rabbit skins; the prayer of the poor prisoners of the Marshalsea; the chimney sweep (considered by the lecturer one of the finest songs in the whole series); the vendor of marking stones for marking linen; the rat-catcher; the ink seller; vendors of rosemary and bags and sweet juniper; ''Kind-heart,'' the tooth-drawer; and ending with a picture of old London — the night-watchman's cry of ''Lantern and Candle Lights! Hang out, Maids.''

Sir Frederick Bridge concluded his lecture by giving an example of a very familiar Good Friday morning cry, which he used to hear in his boyhood days as a chorister at Rochester Cathedral, when men and boys went through the streets crying ''One a penny buns, two a penny Hot Cross Buns.'' That song, he said, was the only bit of modern music the audience had heard that afternoon, as he had written it specially for the occasion; the tune, however, was taken from a very old source.

On the motion of the Chairman, Mr. Carmichael Thomas, a hearty vote of thanks was accorded to Sir Frederick Bridge for his most interesting lecture, and to his friends for the valuable help they had given in rendering so efficiently the various musical selections.

PROCEEDINGS OF THE SOCIETY.

FRIDAY, DECEMBER 17TH, 1920.

MR. OLIVER R. H. BURY, M.INST.C.E., IN THE CHAIR.

THE CHAIRMAN, in opening the meeting, said he had been asked to preside owing to the unavoidable absence of Mr. Acton Davis. He was the Managing Director of the Peruvian Corporation and was responsible for the working and management of the railway which traversed nearly the whole district with which the paper to be read that evening would deal. He was very much interested in Peru and had visited it as recently as the previous September, and he thought that the sooner Colonel Stordy began his work there the better. He had asked Colonel Stordy and also Professor Barker if during the evening they would explain to him the difference between hair and wool in such animals as the sheep, the llama and the alpaca, on which subject there seemed to be some confusion.

The following paper was then read:—

THE BREEDING OF SHEEP, LLAMA AND ALPACA IN PERU, WITH A VIEW TO SUPPLYING IMPROVED RAW MATERIAL TO THE TEXTILE TRADES.

By COLONEL ROBERT J. STORDY, C.B.E., D.S.O.

The paper which I have the honour to present to you to-night has been written at the request of a number of friends and others interested in the development of the South American States, and I am glad, indeed, to place what information the paper contains at the disposal of the Royal Society of Arts, a Society which, in general, assists in the advancement of Science in connection with the Arts, Manufactures and Commerce. I take this opportunity of thanking the Chairman and Council of the Society for the privilege they have accorded me.

With the mention of Peru there is conjured up in the mind visions of unbounded wealth, mystery and fable; such wealth that ''the pots and pans and kitchen vessels were of gold or plate,'' and such mystery and fable as hides from our ken the origin and civilisation of the great Incaic dynasty.

It is not, however, with the mysterious and fabulous that I wish to deal to-night, but rather with the development of those vast pampa lands which lie between the Cordilleras of the Andes, a development

which, so far as I can gather, has never received the attention which their potentialities demand.

Peru, in fact, has never possessed any particular reputation as a stock raising country, and before I left London last year to visit Peru, I was unable to obtain any reliable data as to its possibilities in this direction.

To obtain information in regard to its mineral wealth, I found little difficulty, but I venture to assert that the breeding and rearing of livestock should prove more valuable to the Republic than its mines. I make this statement for the reason that, while rich properties may produce for the moment a better revenue to the State, and provide a certain amount of employment to its inhabitants, the proceeds accruing therefrom, as a rule, immediately leave the country; moreover, the life of even the most profitable mine is measurable and cannot be held to increase a country's permanent prosperity.

General Archibald Cooper, well known as Chief of the Inland Waterways and Docks, during the war period, and now Representative of the Peruvian Corporation in Lima, came to the conclusion, during a tour of inspection of the Southern Railway Systems of Peru, that the immense Andean tablelands traversed by the Railway could maintain a much greater number of sheep and other stock than they had hitherto done. He laid his arguments in due course before the President of the Republic, Senor Alberto Augusto Leguia, who readily appreciated their import -hence my invitation to visit Peru to give what assistance lay in my power, an invitation, the acceptance of which was made possible through the kindness of His Majesty's Secretary of State for the Colonies seconding me for this service.

A sojourn of six months in the Republic, during which time I travelled over the entire length of the Southern Railway and visited the vast tracts of country adjacent thereto, enables me to state that the stock industry of Peru, if developed along sound and progressive lines, should prove to be the principal industry of the Southern portion of the Republic. With the advancement of this industry, other avenues of trade will be opened up, and the lands of both Sierra and Cordillera, now sparsely inhabited, will become centres of prosperity and wealth.

With the completion of that triumph of engineering—the Panama Canal—uniting, as it does, the two maritime highways of the world, Peru is brought within reasonable distance of Europe, and a voyage which in former days occupied close on two months, can now be accomplished within 25 days, a big factor to be considered when discussing the country's commercial development.

Peru, some 680,000 square miles in extent, and with a population of 6,000,000, of whom half are aborigines, is situated between the parallels of latitude 1½° N. and 19° S. It has a coast line of close on 1,400 miles in length, possesses a delightful climate and scenery of wondrous grandeur and beauty.

Lima, the capital, has a population of 250,000 inhabitants, and although this population is cosmopolitan in character, the ancient city retains much of the traditions and customs of its Spanish conquerors.

With a view to giving some small idea of the country to which I wish to direct your attention to-night, a number of views will be projected in rapid succession to illustrate its varied conditions of life and scenery, its cathedrals and churches, the massive architecture and engineering skill of the Incas, which enrapture the minds of all interested in the history of this lost civilisation, and with a passing glimpse of that great inland sea--Lake Titicaca we shall betake ourselves to those vast Andean tablelands where the wool and hair bearing animals of Peru find their home.

It was on Boxing Day last year that I first set foot on Peruvian soil, and on the last day of 1919, I found myself being transported along the Central Railway, rising in the course of a few hours to a height of close on 16,000 feet above the level of the Pacific.

New Year dawned to find me in the throes of a violent attack of soroche--mountain sickness. The symptoms of mountain sickness are a peculiar mixture of *mal de mer* and malaria fever, and as a combination, I cannot say that they merit recommendation.

Not until heart and brain have become accustomed to the rarefied atmosphere and the lungs to a diminished supply of oxygen, can one thoroughly appreciate work or travel in these high altitudes. Provided, however, heart and lungs are sound - and to all who essay visits to these

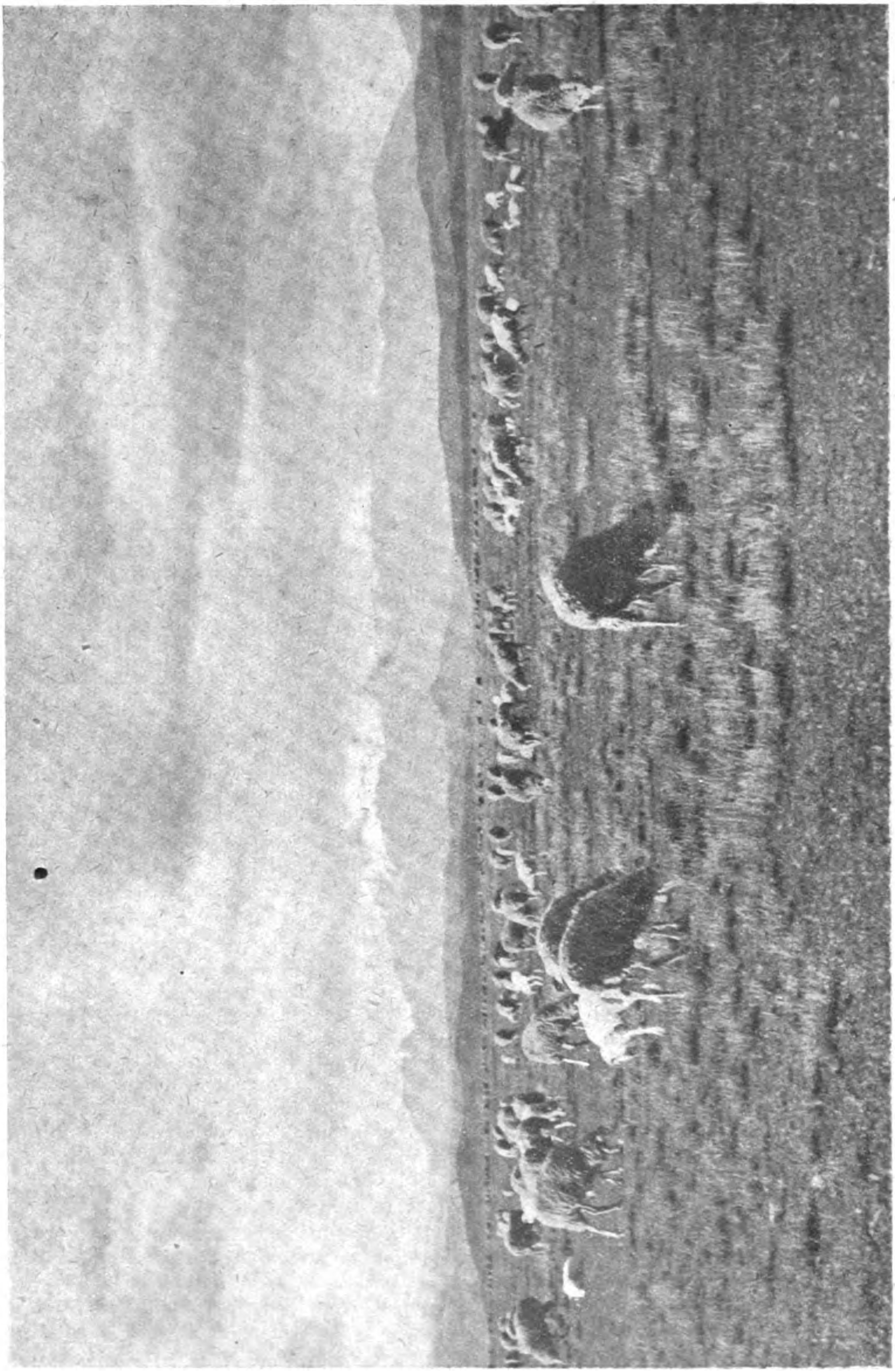

Fig. 1.—View of the Extensive Pampa Land in the Peruvian Cordillera.

regions, it is essential they should be— acclimatisation is rapid, and even after a comparatively short residence on "the roof of the world," one can play quite a stiff game of tennis without inconvenience.

When I told a Club mate of mine a few days ago that my work in Peru demanded residence in the vicinity of 13,000 feet above sea level, he remarked, "Well, Stordy, it is the nearest to heaven you'll ever attain," to which I replied, "I have at least the advantage of a good start on your own celestial aspirations."

It was, however, with slow step and a throbbing brain that I paid my first visit to the sheep farm of Atocsaico, the property of Messrs. Duncan Fox and Co. Here, at an altitude of 14,000 feet, Scotch shepherds, under the able direction of Mr. MacKenzie, had worked for 13 years, bringing their expert knowledge to bear on the problems pertaining to sheep farming in these high places of the earth's surface.

Their labours had not been in vain, and the inspection of flock after flock of pure and cross bred Romney Marsh and pure and cross bred Merino, was both edifying and encouraging, and I carried away with me much valuable information which very materially assisted me when carrying out a survey of the Southern pasturelands.

In pre-hispanic days, the Incas knew naught of horse, mule, ox nor sheep, and it was not until 1532 that importations of the domestic animals of Europe were made by the Spanish. From then until now, the introductions of fresh strains of blood have been few and far between, with the result that the once pure-blooded Spanish Merino sheep presents a woefully degenerate picture, so degenerate that the live weight of a full-mouthed sheep—a sheep of four years old—turns the scale at 40 to 45 lbs., produces a fleece of 1 to 1½ lbs., and yields a dressed carcase averaging 25 lbs. in weight. A Suffolk lamb under twelve months old weighs approximately 190 lbs. live weight.

With ease, the Indian flockmaster slings a sheep on his back to transport it from place to place; it would be a matter of some surprise were he called upon to carry some of our early lambs to the Smithfield Market.

Apart from the in-breeding, which is the main cause of this retrogression, altitude tends to dwarf the species, and, to keep flocks up to a good standard, the frequent introduction of robust stud animals is essential.

The flock increase, too, is materially affected in the Peruvian highlands, and among the flocks of the natives, an increase of only 40 to 45% is recorded.

Degeneracy, haphazard breeding, want of care and an entire absence of animal management cannot be held to improve matters in this direction.

The wool industry, as one might imagine from what has already been stated, is also in a primitive state of development.

During shearing operations the sheep's four feet are bound together as if it were some cloven hoofed monster; in place of shears a knife is used, but, should the knife prove blunt, then a piece of glass suffices. Here is a picture of the operation, and another of the shorn animal—surely a knife and fork would have turned out better class workmanship. Notwithstanding these crude methods, considerable quantities of wool find their way to the World's markets from Southern Peru, and as my friend Professor Barker will be able to tell you to-night, the wool from the degenerate Peruvian merino possesses qualities which merit attention and which prove that it is capable of rapid improvement by judicious selection and breeding.

Fleeces of average weight, sound staple and good handle, with marketable carcases of good flavour and a flock increase amounting to 70 and 75%, amply demonstrate the eminent work of the Scotch shepherds at Atocsaico. The progressive Peruvian farmers, alas! sadly few in number, are beginning to reap like rewards as a result of their labours.

Such results go to show that a highly profitable and important industry can be established in Peru, and while the carrying capacity of the pasturelands leaves much to be desired, sheep, properly husbanded, will prove the best pioneers to create more favourable conditions for promoting the growth of the indigenous pasture grasses, many of which are of considerable economic value.

Generally speaking, the climatic conditions of the regions that I have inspected are *prima facie* favourable to the breeding of sheep, as is evident from the fact that sheep have existed there since the middle of the 16th century, and to-day, there are approximately 6,000,000 head in the Puno Department of Southern Peru.

There is to-day, as you are all aware, a marked congestion in the Wool Markets of

the World, and it is estimated that there are on hand some 4,000,000 bales of wool of all classes of which Britain holds 2½ million bales. At first sight, this amount seems to overwhelm one, but when it is considered that the entire stock represents only one third of the World's annual consumption, it will be realised that the congestion can only be of a temporary nature.

This congestion is due to the following causes:—The devastating effects of War which have seriously disorganised the cloth mills of Belgium and France, Germany's inability to obtain supplies of raw material, and the continued strife in Poland, Finland and Russia. Again, the increased price of all classes of woollen fabrics have placed many of them beyond the reach of the normal consumer, and the large quantities of low graded and wasty wools which reached England during the War have helped to swell our surplus stocks.

Prior to the War there was every indication of a World increased demand for wool, and to-day there is strong evidence that the World's production of the finer wools will fall short of the estimated requirements for the manufacture of higher class fabrics.

Peru, for the present at any rate, cannot hope to compete in the mutton markets of the world, and as the demand for frozen meat grows annually greater, sheep farmers have been encouraged to cross their fine fleeced merinos with the carcase producing English breeds, resulting in a cross bred wool, which, while eminently useful, has to a great extent, lost its fineness and soft handle. Thus the quantity of fine wool grows less and less year by year. The conditions obtained on the Andean tablelands are eminently suited for the production of fine wool, the pasturelands are free of burrs, grass seeds, and other vegetable impurities which militate against sheep farmers in other parts of the World, and which necessitate the application of the expensive carbonising process with its attendant deleterious effects.

Above all, there is an absence of nonpreventable disease in the regions of the Sierre and Cordillera, and the Government, under its able and progressive President, is adopting measures to prevent its introduction—as an earnest of those endeavours two experienced Members of our Royal College of Veterinary Surgeons are being appointed for service at the Ports of Callao and Mollendo.

The Government of the Republic is fully alive to the advantages which will accrue to the State from the development of its wool and hair industry, and a model sheep farm is about to be established where up-to-date methods of sheep husbandry will be demonstrated, and pure and graded stud animals reared and distributed.

With this in view, a number of Scotch shepherds are about to proceed to Peru, taking with them stud animals of excellent quality purchased from well-known breeders of this Country and a number of Rambouillet rams from the National stud fold of France.

We now turn to a short discussion of the wonderful indigenous hair-bearing animals of Peru, the llama (ilyama), alpaca, guanaco, (wanaco) and vicuna (vicunya).

These animals are little known to commerce, and are really little known outside of the Andean uplands of South America.

It was on that memorable day in the year 1511, when Vasco Nunez de Balboa scaled the "peak of Darien" and looked for the first time on the mighty waters of the Pacific, that he was given more definite details of the civilisation existing away in the South, and was shown drawings of the llama.

The camels of the Old World and the llama and allied species of the New, all belong to the same family, and while the Genus *Ovis* is to be found over the four quarters of the globe, the llama and its kind demand conditions of environment which markedly restrict their distribution.

The distribution whereby representatives of the same species are to be found in widely separated regions of the earth, is explained by the zoologist to be due to the fact that in the distant past, the *camelidae* enjoyed a wide distribution, and that conditions favourable to survival have been found in widely separated places.

Even along the extensive ranges of the Andes the llama and alpaca are not found North of the Equator, because throughout the whole extent of the Northern Cordillera, the natural food of these animals, ichu, a coarse fine pointed grass, is not to be found; thus it may be said that only in the mountain fastnesses of Peru and Bolivia these animals abound.

The llama and alpaca have been domesticated from the remotest antiquity.

The aborigines of Peru, according to Garcilasso, looked upon the llama and

alpaca as a present from heaven without which they could neither subsist, trade nor travel. In the 12th Century it is said they adored the white alpaca as their principal and presiding deity, offering unto him sacrifice.

In ancient days, the llama and alpaca formed the main meat supply of the Inca population; on the backs of the llama—for the alpaca is never used for transport, but herded in flocks—gold, silver, copper and merchandise were transported over the rough winding pathways of the impenetrable Andes, and its coarse hair supplied the lower classes with the raw material from which they wove their vestments and blankets; even the dried dung of the llama and alpaca provided the only available fuel in those barren regions.

It is not to be wondered at that the Aymara and Quecha Indians looked upon them as their most cherished possessions.

The members of the species find a congenial home in the elevated regions of the Peruvian and Bolivian Cordillera, and as they do not thrive below an altitude of 9,000 feet, it would appear as if an air, both light and pure, were necessary for their well-being. Attempts have been made in the past to introduce them into Australia, but this met with distinct failure, as suitable conditions could not be found.

It is true that the llama is found working at lower elevations, and that it can even find pleasure and profit within the confines of Regent's Park; still, it neither retains its condition nor quantity and quality of fleece which it possesses in its natural habitat. The alpaca does not thrive when permanently removed from the high altitudes, and it is seen at its best in its mountain home on the Andean wind-swept uplands at 13,000 feet above the sea.

FIG. 2.—HERD OF LLAMAS.

Higher still, courting the regions of eternal snow, the guanaco and vicuña, the wild members of the species, are found, where, safe and secure in their lofty solitude, they browse on the mosses and sparse vegetation of these inhospitable heights.

It is a scientific fact that the more poorly a sheep is fed, the finer wool it produces, a truism which finds ample confirmation

when one sees fine fleeced herds of vicuña grazing on the apparently barren slopes of the Andean range.

The llama is the largest of these Andean camels. It is extremely docile, but sensitive to ill usage. It stands 12 hands at the shoulder, and with a neck of 2 to 2½ feet, its average measurement to the top of its head is well over 6 feet. Its length of neck with its head carried loftily, makes the llama appear taller than he really is.

The eyes are large, black, and rather oblong—the pupils soft and expressive. The muzzle is long and pointed, and the nostrils, situated considerably above the end of the snout, are large and dilated. The upper lip is like the camel's, and exhibits a well defined cleft. The under lip is pendulous, a peculiarity which becomes accentuated as the llama grows older, and which is made use of by the Indians in estimating age. The wear of the teeth, too, is used by the Indians as indicative of age, but the information obtained on this point was so conflicting that it has been found necessary to earmark a number of the young llamas born in March last so that authentic and complete data may be obtained in regard to the all-important question of dentition.

The ears of the llama are about four inches, pointed and carried erect while in motion, inclined to lop while at rest, and put back when expressing resentment.

All members of the species grouse and grumble when handled, and when really angry, spit with unpleasant accuracy. The ejecta really consist of a regurgitation of moist cud which is violently blown from both mouth and nostrils covering one with green acidulous semi-digested food. The wild guanaco and vicuña are more prone to express resentment in this way than the domesticated alpaca and llama.

The stomach of the llama is provided with cells for the storage of water, but, unlike its old world confrere, "the ship of the desert," the llama lives in well watered areas and seldom, if ever, requires to make use of a provision directly related to a life on arid sandy wastes.

The llama and its kind are humpless, narrow across the withers, but possess a good back and loins. The body, resembling the fallow deer, has a deep chest with a lady-like waist tapering away under the haunches like the greyhound, the trunk ending in a tail eight to ten inches long. The breast bone is provided with a callosity or pedestal on which the animal rests while ruminating or asleep. The legs are clean and shapely, and terminate in broad cushion-like pads, the two digits of the foot being clothed with black, horny, incomplete hoofs resembling the talons of a bird of prey. The claw-like hoofs are no doubt a provision of nature to support the animal on the frozen and slippery snow. The fore legs, owing to the prominence of the fleeced sternum, have the appearance of being fixed to the trunk below the centre of gravity. On the metatarsals, cicatrix-like markings are to be found. They are similar to the ergots on the metatarsals of the horse, but differing therefrom, in that they lie below the surface of the skin, are covered with horny epidermal scales, and are present both on the outside and inside of the limb. They are probably glands which secrete some odoriferous substance which, brushed off as the animal passes through herbage, leaves a trail whereby animals of the species can find their mates.

The llama is solemn, slow and majestic in motion. The male animal is only used for transport, and is put to work when about three years old. Small packs are used at first, the maximum load of 100 lbs. only being carried when the Indian considers the animal old and strong enough to do so. The baggage llama with its 100 lbs. pack, can cover 1½ miles per hour, and a distance of from 12 to 15 miles per day.

It is recorded that during the days of the Spanish domination, 300,000 llamas were used to transport silver from the mines to the sea coast.

The llama is loaded standing, and as the baggage llama is never shorn, no pack saddle is necessary, the thick springy fleece affording splendid protection to the withers, back and sides.

When travelling in herds, the leading llama is gaily decorated with coloured ribbons or streamers of silk or wool fastened through holes punched in the ears.

The fleece of the llama is thick and coarse, the neck is well covered, but the throat is devoid of long hair; the fleece terminating abruptly along the bottom line of the trunk, has a staple of from 10 to 12 inches in length, and is used principally in the manufacture of sacks and coarse blankets.

The average weight of the llama is 250 lbs., and it has a life of from 10 to 14 years. The young llama is born into the world during the months of February and March, at a time when the elements of the Cordillera are stormy and bleak, and as little or nothing is done for its protection, there is a mortality which could be greatly reduced were simple animal management observed. The llama carries its young for a period of 11 months, and usually only bears one at a time. This is a wise provision of nature, for the young has to be well nourished during the first two or three months of its existence, although, as a matter of fact, the mother is not blessed with an over abundance of milk: the supply is, in reality, scanty; accordingly, prior to the Spanish invasion, the natives drew no milk from their domesticated animals, nor was milk used by any of the South American tribes. Just think of the wonderful mothers there were in these pre-hispanic days when such artificial dietary as Glaxo, Mellins' Food and Nestle's Milk was not required for the nurturing of the infant population, and what a boon to the thrifty housewife in these days of high prices, and often, indifferent milk supply!

The description of the llama serves in great measure to describe the alpaca.

From the commercial standpoint, the alpaca is of greater importance owing to its abundance of fleece, the hair being 7 to 15 inches in length, soft handling and of good lustre.

The alpaca is smaller than the llama, standing about 10 hands high at the shoulder and weighing approximately 180 lbs. The neck is shorter and is well covered with hair, which forms in the region of the throat a distinct Newgate fringe. It has generally a well developed forelock, which descends to the level of the eyes. Its eyes are large, black, expressive and sparkling, a feature influenced by climatic conditions, and from general observation during my peregrinations in South America, it is a charming trait, the monopoly of which is not held solely by the members of the lower creation.

Fig. 3.—Herd of Alpacas.

Frezier asserts that the face of the alpaca has some resemblance to the human one, and from the picture now on the screen

you can form your own opinions.

The alpaca is herded in flocks and is driven into stone kraals for shearing. The same haphazard measures as those adopted for sheep are used for the breeding of this valuable animal, and much is yet to be done by selection to breed animals true to type. A cross breed between the alpaca and the llama has resulted in the production of a hair of good length, lustre and fineness (huarizo), but whether this cross species will create a second generation is yet to be determined. The "suri" type of alpaca, an animal with a distinct curl along the entire length of the hair fibre, is much sought after by the Indian, and is in demand by Leeds and Bradford spinners, for with this naturally curled fibre, cloth of rarity and artistic finish can be manufactured.

No selection has been used in the production of this "suri" type, its advent being the outcome of mere chance breeding.

With few exceptions, practically all the herds of alpaca are in the hands of the Indian, who usually shears the animals once every two years.

Bradford spinners, however, state that recently, a type of hair has reached the English markets described as "short alpaca fleece" which is deficient in length of staple, and is not desirable for the regular purposes of the trade. The ubiquitous tentacles of the Great War found their way, no doubt, even to the uttermost regions of the Andes, where the enhanced prices offered for alpaca hair (much of which was used in producing the familiar khaki cloth) accounts for the shearing of the alpacas at more frequent intervals than was the usual custom. The Indian too, impelled by an unquenchable desire for alcohol, oftentimes shears his animals at short intervals in order to obtain the necessary cash with which to slake his thirst.

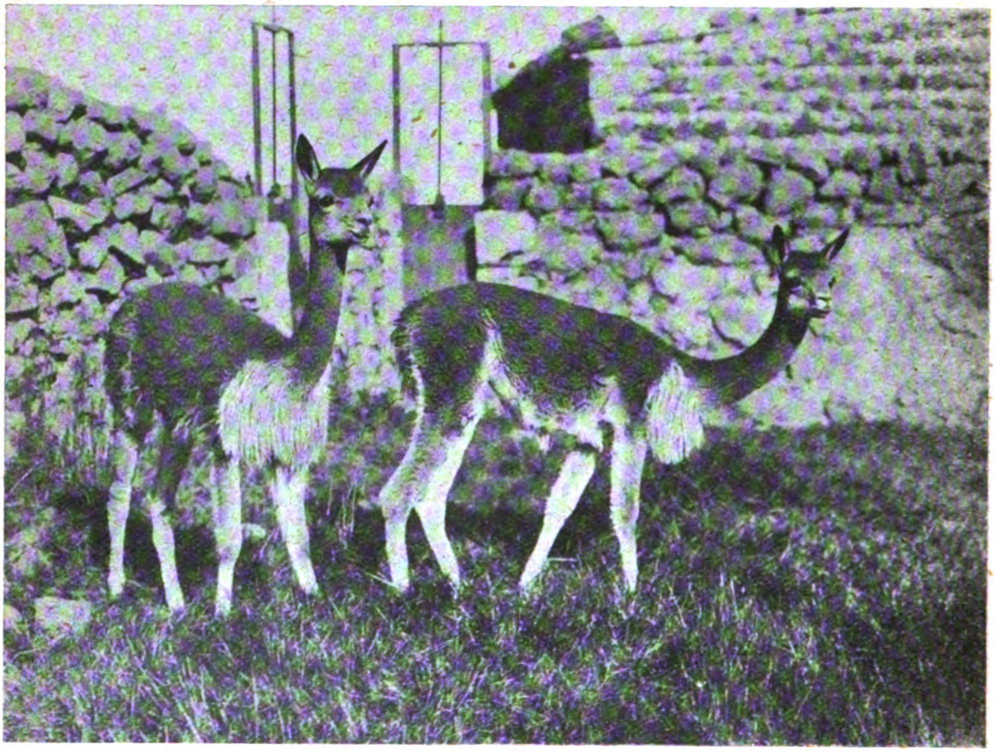

Fig. 4.— Male and Female Vicunas.

The hair of the alpaca is of remarkable fineness and lustre, and there is a variety of colours ranging from white through blue grey, fawn, and orange to dark brown. These colours show abnormal fastness to light and fastness to milling and finishing operations, and Professor Barker, the eminent authority, states that there is a great future for its use in the manufacture of fabrics for Indian and tropical wear.

There has also been a marked development in the hosiery trade in natural coloured

alpaca yarns, and in view of this expansion and the demand for a soft handling fabric, the future prospects for raw alpaca are particularly encouraging.

The annual importation of hair into the United Kingdom from South America amounts to approximately 5,000,000 lbs., of which Peru supplies 3,000,000 to 4,000,000, but until the factories of England can anticipate vastly increased supplies, no new avenues of trade can be opened.

During a recent visit to one of the largest alpaca and mohair factories in Bradford, this fact was strongly emphasized, for supplies are at present only available for the production of fabrics which have been standardised over a period of half a century.

The time seems propitious for earnest endeavours to be made to exploit this valuable industry. Never, in its long history, has the conservation of the alpaca and its species been thoroughly undertaken. Except that during the Incaic dynasty, at a time when other hair and wool bearing animals were unknown, the alpaca and vicuna fibre was so appreciated that the raw material was carefully collected and controlled by the Government, and meagrely distributed to the populace. Surely, during recent days, we, the people in England, have in some measure experienced the influence of a Wool Controller scarcely inferior to that exercised by the Incaic despots.

There are only now the Guanaco and Vicuna left to describe.

The guanaco is the larger of the two—is russet brown in colour with an overmantle of long coarse hair of slightly darker hue. The guanaco inhabits the highest altitudes and is found in greater numbers in Bolivia than in Peru.

It has never been domesticated, nor has it been used for cross breeding purposes.

The vicuna is antelope-like in shape, and both in appearance, colour and movement, recalls the Gerenuk (Walleris gazelle) of Eastern Africa. It stands some nine hands to the shoulder and weighs 75 to 100 lbs. His head is proportionately too large for the size and delicacy of its body.

It is light reddish brown in colour, shading off into light fawn down the legs and along the under surface of the body, and it carries

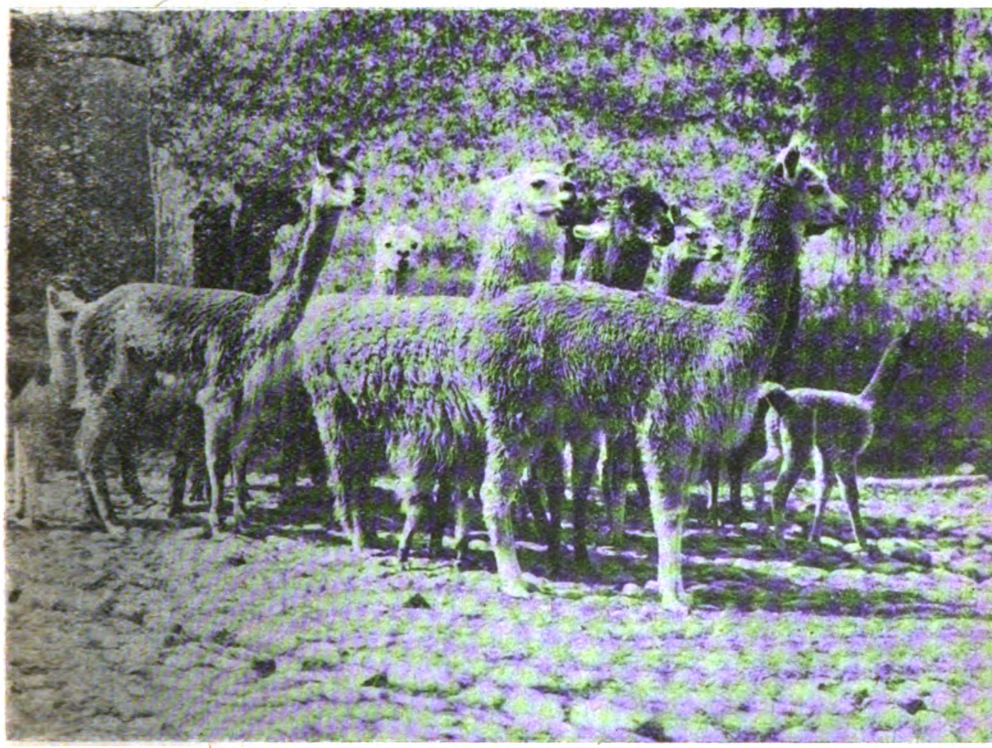

Fig. 5.—In the Foreground, from Left to Right—Male Vicuna, Female White Alpaca, Paco-Vicuna.

a breastplate of long coarse white hair, which drapes the base of the neck and front of the chest.

The hair of the vicuna is extremely valuable. It is more estimable than the down of the Canadian beaver or the fleece of the Syrian goat; indeed, it is so valued in commerce that numerous fabrics are to be found labelled Vicuna, whose composition consists of nearly all the known raw materials except that from which it takes its name.

The vicuna is exceedingly tractable, and during recent years a few Peruvian farmers have reclaimed it from a state of nature and used it for cross breeding with the alpaca, resulting in the production of a hair which for softness of handle and fineness of fibre will be very difficult to equal. A sample of this beautiful product is exhibited here to-night.

It was estimated that in the beginning of the 19th century, some 250,000 vicunas were annually destroyed, a destruction which enormously exceeded their propagation. I am glad to say that the Government of Peru is promulgating laws forbidding hunting or killing of the vicuna and making it illegal to trade in its products, a very necessary provision, for so long as vicuna karosses and ponchos command big prices, so long will this valuable animal be held as the legitimate prey of the hunter.

It is certain that unless very stringent measures are enforced the extermination of the vicuna is imminent.

With a view to supplying improved raw material to the textile trades—a material which can only be produced in the Andean regions of Peru and Bolivia—steps are now being taken to farm those valuable hair-bearing animals along proper and scientific lines, and by a process of selection, judicious breeding, and the application of animal management, to retain and enhance the good qualities which they possess, while eliminating those which are deficient or defective, and by a system of cross breeding, endeavour to produce a hair of even greater intrinsic value. In short, to place on the market a raw material, sound in staple, of good lustre, soft handle and of standardised length.

FIG. 6.—MALE VICUNA WITH HIS PROGENY, PACO-VICUNA, A CROSS BETWEEN THE VICUNA AND ALPACA.

Within the narrow compass of this paper, I have endeavoured to show that,

in the great Peruvian Cordillera, there lies a future pregnant with possibilities, and that in the practice of sheep husbandry and the conservation and scientific development of the alpaca and vicuna hair industry, there are commercial prospects of considerable extent and value

Peru, with only some 6,000,000 inhabitants, through the length and breadth of her vast realm demands, above all things, a working population, and it is hoped thatthe Government of the Republic, with its present progressive policy, will still further advance her best interests by throwing open large tracts of land for colonization on an extensive scale.

There are at present a large number of ex-officers and men of the British Army who might be glad to avail themselves of the amenities of an outdoor life, amongst healthy and invigorating surroundings, whose habits of discipline and appreciation of work would make them desirable members of the community, and who could with honest labour, not only reap benefit to themselves, but do much to raise Peru to that position among the wool and hair producing countries of the world, which her natural advantages dictate.

DISCUSSION.

The Chairman said he was sure everyone present was indebted to the author for his most interesting paper and for the delightful slides he had shown. The paper dealt with a country that was very little known amongst English people, and it afforded much food for thought.

Prof. A. F. Barker (Department of Textile Industries, Leeds University) showed a number of lantern slides and drew attention to their most important points.

The first slide showed the diameters and lengths of coarse alpaca, fine alpaca, coarse alpaca and fine alpaca crossed, and fine alpaca and vicuna crossed. The diameters varied from 1/700″ in the coarse alpaca to 1/1500″ in the fine alpaca and vicuna crossed, and the length varied from 8″ in the coarse alpaca to 2.6″ in the fine alpaca and vicuna crossed.

The next slide answered the point raised by the Chairman as to the difference between hair and wool. It showed two fibres of hair, one dark and the other light, the peculiar cell structure being noticeable. The most interesting work on the subject, it was stated, had been carried out by Prof. Ewart, of Edinburgh University, when he undertook to lecture to Australian students attending Leeds University. After some investigation it appeared pretty certain that the wild sheep originally had two coats, one of hair with the cell structure shown, and the other of wool, which had a scale structure very different from the cell structure of the hair.

The scale structure was shown in the third slide. Curiously enough, some of the sheep or wool-bearing animals lost their wool and retained their hair in tropical countries, and in colder countries they retained the wool and cast most of the hair. The author showed one slide of the vicuna where just the remains of the hair, from the breastplate, could be seen. Probably the animal originally was covered with hair but lost that, while the under-coat, or down wool, corresponding with the down in birds, had been left, with the result that the animals now had remarkable skins with wonderfully fine hair.

The next slide was a table showing the average length and diameter of fibre of all the wools forwarded by the author. It would be noticed from the Table that three of the samples reached 1/1,000″ in diameter. The coarse fibres were not remarkably coarse in comparison with other wools, and the fact remained that sheep reared at the highest altitude gave the finest fibres, which bore out exactly what the author had observed for himself.

He naturally thought that the Peruvian merino ought to be compared very carefully, under precisely similar conditions, with Australian, Cape and South American merinos, and the next slide showed the result of that comparison, which was rather remarkable. In the coarse and average wools the fibre diameter varied slightly in the different countries, the Peruvian being the smallest diameter in both cases, *i.e.*, 1/833″ in the coarse and 1/916″ in the average, while in the fine wools the diameter was about the same for all the countries, *i.e.*, 1/1,000″. The curious point about the waves was that they were very deep, which gave the Peruvian wool a peculiar quality. With regard to length, the Peruvian wool was reasonably long, being 2.83″ in the coarse grade and 1.5″ in the fine. The yeild of the fine wool was 75 per cent. The yield was much higher in the Peruvian merino than in the others, being 76 per cent. as compared with Australian 55 per cent., Cape 48 per cent., and South American 58 per cent. Difficulties had been experienced in developing the merino flocks at the Cape quite as great as were ever likely to occur in Peru. The result of the comparison showed that there were considerable possibilities for merino wool in Peru, and if improvements were made on the lines suggested by the author he thought it would be realised that the prospects were very hopeful.

The next slide showed the alpaca fibre and the merino fibre. It would be seen that the former was the finer and, strictly speaking, it had a scale structure, and, therefore, was wool rather than hair.

The next slide showed a comparison of llama, llama and alpaca crossed, alpaca, alpaca and vicuna crossed, and vicuna. The fibres from which the comparison was made had been supplied by the author, and all those interested in the subject were very much indebted to him for having afforded the opportunity of making such a comparison, which it was hoped would be published, as the intention was that the results should not only be appreciated but be made use of. The diameter of fibre in the fine grade of the alpaca was as fine as that of the vicuna, *i.e.*, 1/2100", but coarse fibres were found in the alpaca, whereas the vicuna was more consistent. The diameter of fibre in the alpaca and vicuna crossed was 1/1500" in the fine grade. He did not think such fine fibres in the alpaca had obtained the consideration they ought to have had, and if sufficient quantities could be obtained there would probably be a very marked development in their use.

The next slide illustrated the difference between pure llama and llama and alpaca crossed, the pure llama fibres being the coarser of the two. In the fine grade the diameter of fibre in the pure llama was 1/700" to 1/1000", and in the llama and alpaca crossed it was 1/900" to 1/1000".

Tests were made to find out the relative strengths of alpaca and wool yarns. In the first place the jaws of the testing machine were placed close together and the fibres broken, and it was found that on the average the alpaca was slightly stronger than the crossbred wool. Then the jaws of the testing machine were placed 18" apart, and there was a very marked diminution in the strength of the alpaca, the cross bred wool being very much stronger. That was because the fibre did not break at all in that case but slipped, and it was the very slippery character of the alpaca which made it especially valuable to the manufacturers of certain cloths. The results of the comparison were, generally speaking, very favourable to alpaca. He was very doubtful as to the truth of the statement that alpaca was liable to crease. From the experiments he had made, he had found that if the fibre was properly spun and the cloth correctly made, creasing need not take place in the way it was said to do.

In the vicuna, alpaca and llama in Peru, the male appeared to grow a coarser fibre year by year, and the female appeared to grow a finer and longer fibre year by year. The wool could be kept on the animals for two or three years. Great difficulty was experienced at the Cape in breeding sheep that would retain their wool. It seemed to him that the climate in Peru obviously tended to make the sheep retain their fleece rather than cast it, as was the case at the Cape. The length of a two years' growth of fibre in the alpaca was, as the author had said, a very valuable quality in manufacture. A two years' growth of fibre was found to be the most suitable (shearing every other year), and there was a beautiful uniformity of fibre right along the staple, which made it very valuable.

The higher up the animals were bred apparently the better the wool became. That was rather an astounding discovery to make, and it was one that even the sheep breeders in this country ought to note.

The colours of the alpaca, vicuna and llama, were certainly worthy of very careful consideration. Curiously enough, they seemed to be faster to light than those of the sheep in this country. His colleague, Prof. Perkin, had made certain suggestions to him as to the possibility of fastening the natural colours of the wool obtained from sheep in this country, but it seemed that in the case of the alpaca the natural colours did not require that. Those natural colours were not used at the present time to the extent to which they ought to be used. Fortunately he had been able to take the author to one of the large Bradford firms, Messrs. Foster of Queensberry, where they were shown some of the hosiery yarns being made from natural colours, and very beautiful yarns they were.

The next slide showed the yearly exports of woollen yarn, worsted yarn, and alpaca and mohair yarn from 1900 to 1919. From 1915 to 1919 very little alpaca and mohair were exported, the quantity being only 2,219,560 lbs., as compared with 15,453,760 lbs. from 1910 to 1914. When the British manufacturers could not get wool during the war, they began to look for something to take its place, and they discovered a valuable fibre in alpaca, which had been used for many other purposes than it was used for previous to the war. Some of the woollen manufacturers did not discover the qualities of certain English wools until they were obliged to use them owing to war conditions. Then they discovered that those wools were really the finest that could be used for certain purposes, and consequently certain English wools of the Down type had claimed such attention that their price was the highest.

In the next slide the quantities of alpaca, vicuna and llama wool imported into the United Kingdom from 1863 to 1919 were shown. The amount had steadily increased, the average from 1863 to 1869 being 2,724,294 lbs., and from 1910 to 1919 5,382,660 lbs.

Prof. Barker then drew attention to the samples of fabric which had been lent by Messrs. Foster of Queensberry. One showed the style of fabric Sir Titus Salt manufactured, in the fifties and sixties, on which the great Saltaire works were founded. He wished particularly to draw attention to the wonderful qualities of alpaca, one of which was its quality of shrinking, which meant that it could be used for many purposes which would never have been thought

of as long as only hair was available for that particular type of fabric. The experiments carried out in actual manufacture and the examination of the samples that had been made at Leeds University had impressed him very much with the possibilities of Peru, and he hoped the author would go forward with the great work that he was initiating.

Mr. Walter Woodbine Parish thanked Col. Stordy for a very interesting paper. The experience of certain breeders in improving the quality of the sheep during the last fifteen years in a more southerly portion of South America than Peru might be of some interest. The early nineteenth century coloured pictures of guanaco, llama, vicuna and alpaca that the author had shown on the screen he recognised as being from a book published in 1811 by a writer named William Watson. In the dedication of that volume, to Lord Sheffield, Mr. Watson drew attention to the extraordinary development that had taken place amongst the Spaniards in dealing with Peruvian sheep, but the point of the dedication was that he wished to introduce the guanaco and llama into England to improve the breed of English sheep, which appeared to be precisely the reverse of what the author of the paper they had listened to had suggested! Merino, the finest type of wool, naturally brought to mind Australia, and Australia, he believed, had no indigenous sheep at all. It has been stated that the first sheep which were taken to Australia some 150 years ago were Bengalese, then followed the South African or "Afrikander," while the first merino—taken to New South Wales—came from the Rambouillet stud that was built up by King George III., from importations from Spain. The Australian merino had been imported to South America, and in Patagonia for the last fifteen years most interesting experiments had been carried out, not only in breeding a pure merino, but by crossing the merino with the Romney Marsh. Prof. Barker had shown on the screen the difference in length between the alpaca and various types of wools. Some fifteen years ago, Patagonian merino was very short in length, had no character, and was a wool that commanded but a small price in the market. By the introduction of pure bred merino from Australia, and by utilising the services of men who had been born and brought up in the sheep districts of Australia, various companies had managed to breed a type of merino which within the last few years had shown a great improvement in both length and quality. The author had drawn attention to the fact that the higher the altitude the finer the fibre. In Patagonia, experience had not always proved that that was the case, although it might do so in the future. Certainly in the northern parts of Patagonia it had been found that in the central region, which was exceedingly dry, a finer merino was grown more successfully than was possible in the region of the Cordilleras, some 200 miles further west. The rainfall in the central districts of northern Patagonia averages barely eight inches a year, and with that very small rainfall an exceptionally fine type of merino sheep had been gradually evolved. In the Cordillera district the rainfall varied from 16 to 30 inches a year, while there was also a considerable amount of snow. In that district it was found that, although the merino could be grown, it did not give such a fine wool, though, on the other hand, the cross Merino-Romney Marsh had proved an excellent dual purpose type which did well, but could not be produced in the central part of northern Patagonia. The question of breeding sheep seemed to resolve itself, therefore, into finding out what type of sheep a specified district would grow, this depending on the pasture and on the weather. He hoped that the researches the author was going to carry out would lead to success in Peru, and judging by the experience in other parts of South America there seemed no reason why with patience and scientific management a suitable type of sheep could not be brought into being.

Mr. J. R. Yates said that nearly twenty-five years ago he had the pleasure of listening to a very interesting paper read before the Society of Arts by a young Peruvian, who endeavoured on that occasion to show the great possibilities of Peru. Two days ago a letter came into the hands from his Peruvian Embassy in New York, written by that same gentleman, who to-day occupied the position of Peruvian Ambassador to the United States. In the letter, the writer expressed his great indebtedness to the people of this country for the kindness he received whilst he was here. That fact was interesting, as showing the connection and interest which might very well exist between Britain and Peru, and he thought the paper that Col. Stordy had just read could not fail to rouse a feeling of great interest for that land of fascination and mystery. He hoped the paper might be read in many other places in this country, and if the result of it was that English people—particularly those of Leeds and Bradford, and others who were interested in the wool industry—directed their attention to the great possibilities to which the author had referred, his efforts would not have been made in vain. Everyone present must feel very grateful to the author for his admirable paper, and would hope that his work would meet with success.

The Chairman (Mr. Oliver Bury), in proposing a vote of thanks to the author, said he thought it would be a good thing if Col. Stordy could repeat the paper in Spanish to the Peru-

vians, as they were the people who ought to act in the matter. Speaking on behalf of those interested in the railways of Peru, he might say that they would like the Peruvians to adopt the author's advice on a very large scale. It was an interesting fact that the weaving industry was the oldest in the world, and he believed the best authorities on weaving said that the oldest records of any weaving in any part of the world were in certain parts of Persia and in Peru. About two months ago he saw some mummies that had recently been discovered, and which were said to belong to very early pre-Inca days, and those mummies were clothed in the finest woven garments of vicuna wool. With regard to the wool becoming finer or coarser according to the climate, his experience in the Argentine had been that if a sheep was sent from a cold country to a warmer one, it put on a thin coat, and a thin coat meant coarser wool. The altitude and crossing of the different breeds, however, had something to do with the matter.

The resolution of thanks was carried unanimously.

Col. Stordy, in reply, said that with regard to hair being developed at high altitudes and cold climates, the indigenous sheep of tropical Africa grew hair and hair only.

The meeting then terminated.

USE OF CIBUCAO WOOD FOR DYE IN HONG-KONG.

The importation of cibucao wood from the Philippines and its manufacture into a stain or dye, in Hong Kong, are in the control of a close combination of five Chinese firms in Hong Kong. The wood, called "Soo Mook" in Chinese, comes almost exclusively from Iloilo and vicinity in the Philippines. It is a red, fairly soft wood, and is cut and cured in short lengths and imported im bundles. It is bought and sold by the picul (133⅓ pounds). The stain or dye manufactured from the wood is a red ink or paste used largely by the Chinese for inking the small "chops" or seals employed by them as the means of affixing their signatures to written instruments of a formal nature.

The colour in the wood is extracted and used variously by the Chinese as an ink, a stain, dye and paint colour. The wood is boiled and the resulting water solution is further boiled down to a syrup-like consistency. Whiting is then mixed with it for most purposes, the resulting paste being the preparation used as an ink for the native "chops." As a dye the stain is used for colouring cheap Chinese papers, notably the paper used in the manufacture of fire crackers, ceremonial papers of various sorts, and for the very cheapest kind of Chinese stationery. The whiting concentrate also is used as an adulterant for European red paints. The colour liquor is used at times for mixing with better quality of red dyes for colouring native cloths.

The whole process of extracting the dye, writes the U.S. Consul-General in Hong Kong, is crude and wasteful, but the business is closely controlled by this syndicate, which is strong enough to regulate the volume of the manufacture and the price of the product. It is doubtful, therefore, whether it would be practicable to transfer the industry to the Philippines and have the dye or stain manufactured there for sale in China, although apparently there would be a considerable saving in freight and other expenses by so doing.

PRODUCTION OF ATTAR OF ROSES IN BULGARIA.

During the 12 years prior to the First Balkan War, that is, from 1900 to 1912, the manufacture of attar of roses in Bulgaria attained its highest development, and a large number of factories equipped with modern steam stills were erected. The total area planted to roses, in the same period, increased to more than 20,000 acres. Owing to the three wars in which Bulgaria has taken part since 1912, the industry of rose culture for the production of attar of roses has experienced a decided setback. It is estimated that the present acreage planted to roses is not more than 15,000.

The average annual production of attar of roses in the years 1900 to 1912, was about 126,800 ounces. The quantity fell to 85,000 ounces in 1917, 85,000 ounces in 1918, and 52,000 ounces in 1919; it is predicted that the present year's yield will show a further decrease

During the war, owing to the fact that Bulgaria was cut off from the principal markets —New York, London and Paris—the stocks of attar of roses remaining unsold increased until they reached a total of about 275,000 ounces, about 40 per cent. of which is said to have been of inferior quality. About one-third of this total available stock was sent to the United States early in 1919, in part payment for flour imported from the United States; also some 17,000 ounces were shipped to the United States during the last quarter of the year. In the spring of this year, it was estimated that the available stock in Bulgaria hardly exceeded 50,000 ounces, worth about £100,000.

It is stated, on the authority of one of the best-known producers, that under existing conditions the production of attar of roses is not a paying industry. Owing to the high prices for other farm products, at least 5,000 acres of rose gardens have been abandoned and the land planted to more remunerative crops, especially tobacco. Centralization by the formation of a syndicate for the purpose of eliminating unnecessary expenses, is spoken of as the only course that will save the industry.

GENERAL NOTES.

Concrete Posts as Mine "Timbers."—*The South African Mining and Engineering Journal* refers to the invention by a Belgian engineer of hollow concrete posts for use as mine "timbers." The device consists of a hollow reinforced concrete column, filled with sand or some other slightly compressible material through which the load is transmitted. The arch for the roof is of pre-cast concrete, and is provided with a tenon which fits into the opening of the hollow post. The bottom of the post fits over a tenon on a base block. Spiral reinforcement is provided for the post which has to resist, at the beginning of loading, the radial pressure of the sand filling the hollow and compressed under load on the frame. If the roof settles, the sand will compress to a certain extent, and if the amount is beyond the length of the tenon, the post begins to take the compression.

Alfa in Tunis.—Alfa, which grows wild on the hot dry plateaus having permeable subsoil, is potentially a very important article in the foreign trade of Tunis. It is estimated that this roaming plant, highly useful in the paper and cordage industries, is found on almost 1,500,000 hectares, and that its production would average 300,000 tons a year if it were cut annually. The fibre is at present harvested promiscuously for unimportant local use, and to supply the foreign demand for high-grade paper material; it is shipped principally to England, which took 1,289 metric tons in 1918, of aggregate exports amounting to 2,086 tons. Before the war reduced shipping facilities, Tunis exported annually 40,000 to 50,000 tons of alfa, and in 1914 as high as 57,630 tons, of which quantity 53,925 tons were sent to Great Britain.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

January 19.—F. M. Lawson, Assoc. M.Inst.C.E., "The Future of Industrial Management." The Right Hon. Lord Askwith, K.C.B., K.C., D.C.L., in the Chair.

January 26, at 4.30 p.m.—A. Abbott, M.A., Assistant Secretary of the Department of Scientific and Industrial Research, "The Origin and Development of the Research Associations Established by the Department." W. Greenwood, M.P., Vice-President, British Cotton Industry Research Association, in the Chair.

February 2.—A. F. Baillie, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World." Professor Sir John Cadman, K.C.M.G., D.Sc., in the Chair.

February 9.—William Rothenstein, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England."

February 16.—William Cramp, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice."

February 23, at 4.30 p.m.—Sir Daniel Hall, K.C.B., F.R.S., Permanent Secretary, Board of Agriculture, "The Present Position of Research in Agriculture." (Trueman Wood Lecture.) Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the Chair.

Indian Section.

Fridays at 4.30 p.m.

January 21.—R. S. Troup, M.A., C.I.E., Indian Forest Service, Professor of Forestry at the University of Oxford, "Indian Timbers." Sir Claude H. A. Hill, K.C.S.I., C.I.E., in the Chair.

February 18.—Paper to be announced later.

April 22.—Sir George Birdwood Memorial Lecture.

May 27.—William Raitt, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

Colonial Section.

Tuesday, February 1, at 4.30 p.m.—G. C. Creelman, LL.D., B.S.A., Agent-General for Ontario, formerly Commissioner of Agriculture and President, Ontario Agricultural College, "Modern Agriculture."

Indian and Colonial Sections.
(Joint Meetings.)

At 4.30 p.m.

Friday, March 4.—William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

Tuesday, May 3.—Sir Charles H. Bedford, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

Sir James P. Hinchliffe, "Research in the Wool Industry."

Sir Herbert Jackson, K.B.E., F.R.S., "Research in Scientific Instrument Making."

Charles Ainsworth Mitchell, M.A., F.I.C., "Science and the Investigation of Crime."

John Francis Crowley, D.Sc., B.A., M.I.E.E.

Captain J. Manclark Hollis, Secretary to the Village Centres Council, "The Re-Education of the Disabled."

Howard Lectures.

Alan E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E., "Aero Engines." Three Lectures. January 17, 24, 31, at 8 p.m.

Syllabus.

Lecture I.—Early Attempts to Produce Motive Power for Flight—External and Internal Combustion Methods—Possible Fuels—Materials of Construction—Steam, Reciprocating and Turbine Engines and Internal Combustion Engines—Development as regards Thermal Efficiency, Power and Weight—Thermodynamic Cycles in Internal Combustion Engines—First successful Engines in Flight—Aero Engines in 1910—Development before 1914—Relative Importance of Weight and Fuel Economy.

Lecture II.—British and German Aero Engines at the beginning of the War—Development of the six main types during the War—Comparison of British and German Practice—Special Experimental Types—Limiting Conditions in Different Types—Supercharging—Examples of Different Types.

Lecture III.—Engines in use after the War—Comparative Tables of Piston Speeds, Mean Pressures, etc. — Conditions Governing and Limiting Further Progress—Variations of Thermodynamic Cycles—Regeneration—Possible Progress as regards Materials—Future Development of Aeroplane and Airship Engines.

Cantor Lectures.

Monday evenings, at 8 o'clock :—

Eric K. Rideal, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures, February 14, 21 and 28.

Major G. W. C. Kaye, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

Samuel Judd Lewis, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

MEETINGS FOR THE ENSUING WEEK *

Monday, Jan. 17..Cold Storage and Ice Association, at the Royal Society of Arts, John Street, Adelphi, W.C., at 5.30 p.m. Mr. C. Bishop, "The Ethyl Chloride Machine."

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rt. Rev. Bishop E. G. Ingham, "Some Reflections on how Empire came to us, and can alone be Conserved."

Transport, Institute of, at the Institution of Civil Engineers, Gt. George Street, W., 5.30 p.m. Mr. M. Stevens, "The Manchester Ship Canal as a Factor in Transport."

Geographical Society, Kensington Gore, W., 5 p.m. Lt.-Col. E. F. W. Lees, "International Aeronautical Maps."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. H. C. Bradshaw, "The Restoration of Praeneste."

Automobile Engineers, Institution of (Scottish Centre), Technical College, Glasgow, 7.30 p.m. Capt. S. Bramley-Moore, "Recent Developments in Transmission."

Tuesday, Jan. 18..Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Mr. A. B. Thompson, "Oil Field Losses and their Elimination."

Illuminating Engineering Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 8 p.m. Mr. J. C. Elvy, "The Use and Abuse of Light in Studios for Cinema Film Production."

Statistical Society, 9, Adelphi Terrace, W.C., 5.15 p.m.

Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Miss H. C. Bowser, "The Buddhist Temples of the Diamond Mountain, Korea."

Royal Institution, Albemarle Street, W., 3 p.m. Col. Sir Gerald P. Lenox-Conyngham, "The Progress of Geodesy in India" (Lecture I.)

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. Mr. H. J. Dowling, "Schools of Art and their Value to the Trade."

Wednesday, Jan. 19..Meteorological Society, 70, Victoria Street, S.W., 8 p.m.

Geological Society, Burlington House, W., 5.30 p.m

School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Dr. T. G. Bailey, "The Thugs—the Assassins of the XVIIIth Century."

Automobile Engineers, Institution of, The Chamber of Commerce, New Street, Birmingham, 7.30 p.m. Mr. T. R. Florence, "Relative Advantages of Two Stroke and Four Stroke Engines."

Thursday, Jan. 20..Aeronautical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Lord Montagu of Beaulieu, "The Cost of Air Ton-Miles Compared with other Forms of Transport."

Pottery and Glass Trades Benevolent Institution at the Royal Society of Arts, John Street, Adelphi, W.C., 7.30 p.m. Mr. H. J. Plant, "The Aims and Products of the Longton Potters."

Royal Society, Burlington House, W., 4.30 p.m.

Linnean Society, Burlington House, W., 5 p.m. Prof. E. H. C. Walsh, "Lhassa and Central Tibet."

Automobile Engineers, Institution of, 28, Victoria Street, S.W., 8 p.m. (Graduates Section). Mr. W. H. Wardall, "Cylinder and Piston Wear."

Royal Institution, Albemarle Street, W., 3 p.m. Dr. A. Harden, "Biochemistry (Vitamines)" (Lecture I.)

Numismatic Society, 22, Russell Square, W.C., 6 p.m.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m.

Friday, Jan. 21..Royal Institution, Albemarle Street, W., 9 p.m. Sir Frank Benson, "Shakespeare and Democracy."

Geologists' Association, University College, W.C., 7.30 p.m. Mr. G. Barrow, "The Origin and Age of Post-Eocene Brick-Earths near London."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Mr. H. J. Smith, "The Mechanical Loading of Ships."

Saturday, Jan. 22..Royal Institution, Albemarle Street, W., 3 p.m. Dr. P. C. Buck, "The Madrigal." (Lecture V.)

*For Meetings of the Royal Society of Arts see page 99

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FRIDAY, JANUARY 21, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 24th, at 8 p.m. (Howard Lecture). ALAN E. L. CHORLTON, C.B.E., M.Inst. C.E., M.I.Mech.E., "Aero Engines." (Lecture II.)

WEDNESDAY, JANUARY 26th, at 4.30 p.m. (Ordinary Meeting.) A. ABBOTT, M.A., Assistant Secretary of the Department for Scientific and Industrial Research, "The Origin and Development of the Research Associations Established by the Department." W. GREENWOOD, M.P., Vice-President, British Cotton Industry Research Association, in the Chair.

EXTRA MEETING.

An Extra Meeting of the Society will be held on Tuesday, February 8th, at 8 p.m., when a paper on "Some Notes on the Problem of Unemployment" will be read by Mr. Edward C. de Segundo, A.M.Inst. C.E., M.I.Mech.E., M.I.E.E. The Chair will be taken by Mr. George James Wardle, C.H., late Parliamentary Secretary, Ministry of Labour.

HOWARD LECTURE.

Monday, evening, January 17th, Mr. Alan A. Campbell Swinton, Chairman of the Council, in the Chair. Mr. Alan E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E., delivered the first lecture of his course on "Aero Engines."

The lectures will be published in the *Journal* during the summer recess.

SIXTH ORDINARY MEETING.

WEDNESDAY, JANUARY 12th, 1921; MR. W. L. HICHENS, Chairman of Messrs. Cammell, Laird & Co., Ltd., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Baeza, Edmund Isaac, Barbados, B.W. Indies.
Bernard, Pierre Arnold, New York City, U.S.A.
Bindley, Captain H. Duncombe, Assoc. M. Inst. C.E., Kuala Lumpur, Federated Malay States.
Blackwell, Miss Clarice Evelyn, Crewe, Cheshire.
Clark, James O. M., Paisley, Scotland.
Crossley, Arthur William, C.M.G., D.Sc., Ph.D., F.R.S., Didsbury, Manchester.
Curtis, Hon. George Seymour, C.S.I., Bombay, India.
Dutt, Nirmal Kant, B.A., Calcutta, India.
Ghosh, Nirmal Kumar, Benares, India.
Gray, Vernon Foxwell, Delhi, India.
Greenwood, John Neill, Stocksbridge, near Sheffield.
Hewett, Arthur Frederick, B.Sc., University of Glasgow.
Jacob, Harry Morgan, London.
Lee Mun Pan, Kuala Lumpur, Federated Malay States.
Lim Nee Soon, J.P., Singapore, Straits Settlements.
Martin, Oswald Stuart, Calcutta, India.
Mawe, Frederick Henry, Malvern Wells.
Mustafi, Chunilal, Midnapur, Bengal, India.
Parish, Walter Woodbine, London.
Platt, Wallace T., Singapore, Straits Settlements.
P'Chient, Peter, Negri Sembilan, Federated Malay States.
Ross, James Watt, E. Molesey, Surrey.
Stordy, Colonel Robert J., C.B.E., D.S.O., London.
Walker, James William Boyd, F.S.I., Pahang, Federated Malay States.
Willson, Walter Stuart James, Calcutta, India.

The following candidates were balloted for and duly elected Fellows of the Society:—

Cotts, Sir William D. Mitchell, K.B.E., London.
Cryer, A. G., Orpington, Kent.
Duchemin, H. P., Nova Scotia, Canada.
Gösling, Bernhard, Bradford.
Hill, Henry Walker, Nottingham.
Liddelow, Colin Coningsby Watson, Negri Sembilan, Federated Malay States.
McArel, Henry, Nova Scotia, Canada.
Pepys-Goodchild, George William, A.M.I.Mech.E., London.

Stokes, Walter Robert, F.R.A.S., London.
Walker, Sydney Joseph, Sheffield.
Wallis, Percy, Kettering.

The Aldred Lecture on "Industrial Fatigue," was delivered by CHARLES S. MYERS, M.D., Sc.D., F.R.S., Director of the Psychological Laboratory, and Lecturer in Experimental Psychology, University of Cambridge.

The lecture and discussion will be published in the *Journal* of January 28th.

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

MONDAY, JANUARY 3rd, 1921.

MAJOR SIR HUMPHREY LEGGETT, R.E., D.S.O., in the Chair.

THE CHAIRMAN, in introducing the author of the paper, said that Mr. Cornell had in his early youth studied the subject with which he proposed to deal, first of all in South America, and then for twenty years in South Africa, where he mined and prospected for gold, silver and diamonds, eventually concentrating his attention more particularly on the latter, especially those obtained from alluvial deposits. In the course of his wanderings and explorations, he entered the territory of German South-West Africa some years before the war, and became a recognised authority on that country, which had now been added to the British Empire. He drew the first maps of that part of the world. When war broke out he became an officer in the British Forces, and personally discovered the first attempted crossing of the Germans into British territory. The services Mr. Cornell rendered then and subsequently during the war, earned him the distinction of an Officer of the Order of the British Empire.

The paper read was—

THE ALLUVIAL DIAMONDIFEROUS DEPOSITS OF SOUTH AND SOUTH-WEST AFRICA.

BY FRED. C. CORNELL, O.B.E.

In 1867, during a period of the greatest depression, in South Africa, when droughts of exceptional severity had killed off a large proportion of the flocks and herds, when a new and greatly resented duty upon Colonial wines had practically resulted in the loss of the Home market, and when, in short, prospects appeared most gloomy, a new lease of life was given to the country by the discovery of diamonds; a discovery which, pooh-poohed at first, was soon amply confirmed, and which was to bring about an industry of tremendous wealth, and of world-wide importance.

The first diamonds were discovered in the district of Hope Town, near the Orange River, but the bands of adventurous spirits which the discovery attracted to the spot, soon wandered to the banks of the Vaal River, where finds were much more plentiful; and it is along the latter river, and not the Orange, that the principal "River Diggings" are to be found.

At first attention was only paid to the gravel adjoining the actual banks of the river, where, by laborious hand-washing, and the primitive methods of the gold fossicker, a modicum of good stones were found, and when, in 1870, the precious stones were found in greater abundance on the farms, Du Toits Pan and Bultfontein, at a considerable distance from them, the deposit was still thought to be an alluvial one; for I need hardly mention that up to that time diamond-bearing pipes were unknown, and the world's supply of the precious stones, either from the East or from Brazil, had always been obtained from gem-bearing gravel.

And for a time these new deposits were known as the "Dry Diggings" in contradistinction to those near the actual river, and they were worked by individual diggers, but it was soon found, not only that they were much richer in diamonds than the river gravel, but that their matrix was neither a gravel nor an alluvial deposit at all. These spots, in short, were the rich mines of the Kimberley of to-day, well-defined volcanic pipes, which have since proved of great depth and importance, and to-day provide the vast bulk of the world's output of diamonds.

Their history does not belong to a paper such as this, and I can only touch upon them. For a time the individual diggers flocked to them, and the River Diggings were almost abandoned, but with the recognition of their enormous value came the gradual elimination of the digger, whose place was taken by syndicates and companies, culminating in the huge combine of to-day.

Meanwhile the squeezed-out digger had drifted back to the banks of the Vaal, and for many years the district in the vicinity of Barkly West was their headquarters. Other small townships sprang into being as the result of "rushes" following the finding of good stones, notably at Windsor-

ton, Hebron, Klipdam, Pniel, Gong-Gong, and dozens of smaller mining camps, but up to 1907 the diggings had practically been confined to Griqualand West. In that year, however, finds in the vicinity of Bloemhof, a considerable distance up-stream, and in the S.W. Transvaal, led to a spread of the diggers in that direction, and in 1910 an extraordinary rush took place to that township, the population of which increased within a few weeks from some 4,000 whites, to nearly 16,000—principally diggers. Finds continued to be made even farther north, and it has been estimated that this diamondiferous area, which extends to Schweizer Rencke, some 35 miles farther north, and to nearly as far east as Klerksdorp, covers an area of some 2,000 square miles.

The principal diggings along the Vaal River, therefore, may be roughly divided into the "Higher" and "Lower" diggings, and may be said to extend from near Klerksdorp in the north, to the Junction of the Vaal and the Orange near Douglas, in the south and for varying distances inland from the banks.

Along this 200 mile stretch of river the gravel, often for miles away from the actual stream of to-day, has been burrowed into as though by an army of gigantic moles; heaps of debris, tailings, and the scrupulously cleaned and graded little pebbles that have been sorted over and over again as "wash," covering the whole of the country, especially in the vicinity of the better known diggings.

Whilst the permanent river townships, such as Barkly West and others I have enumerated, are the centre of the industry (if it can be called one), it is no uncommon thing for the news of a big find some miles away to cause a rush to that locality to the depletion of the permanent settlements; and these rushes, spasmodic, and seldom resulting in many good finds except those that called them into being, are the scene of the most fevered activity. Tents appear as by magic, wagons, Cape-carts, and all sorts of other vehicles arrive and are used as a living place by their digger owners; stores and "hotels" of the flimsiest description are run up, and these at any rate usually thrive.

In short, a new digging, or a rush back to an old spot long since abandoned (as often happens), is the mining camp of the old days of California, or of Australia, over again. There is, however, but little of the rowdiness that belonged to those days, for the diamond digger is as a rule a most law-abiding person, and the six-shooter is conspicuous by its absence.

The diamonds are sparsely and unevenly distributed in the gravel, and their source remains undiscovered and still somewhat of a mystery. For a time the generally accepted theory was that they had been washed from the Kimberley pipes by the Vaal having at some period flowed through or over, the latter, and then been spread over the country with the gravel by subsequent floods or the changing of the river's course. But this theory has long since proved untenable. There is no evidence that the Vaal ever actually ran through the pipes; and again, not only have the diamond gravels been found far to the north—and upstream—of any of the Kimberley pipes, but the diamonds found in the gravel are very dissimilar from those of the mines, and easily distinguishable by an experienced eye.

Another theory, and one which appears highly probable, is that at a very remote period, glacial action denuded certain still undiscovered pipes of hundreds of feet of diamond-bearing magma, which, in its slow journey across the country, has been deposited where geological conditions or formation have been favourable, and that subsequent fluvial action has effected still wider distribution, which has culminated near the present river.

Of glacial action there is abundant evidence in the vicinity of the river itself; notably near Windsorton, Hebron, and Pniel. Another theory which has been advanced by certain geologists is that the diamonds were not formed in Kimberlite, but that they have weathered out from a peculiar amygdaloidal diabase, which outcrops in many places on the river bank, and which shows steam vesicles filled with agate, chalcedony, and other forms of silica in nodules—many of which in a loose state are found in the gravel in conjunction with the diamonds. The gravel, whatever its source may have been, presents many features in common; even in spots so widely separated as those of the Higher and Lower Diggings, the deposits near the Harts River in the vicinity of Taungs, those but recently discovered at Rouxville on the Orange River, the huge terraces near the mouth of the Orange (many

hundreds of miles from the last-named deposit) and the deposits, so rich in tiny gems, of the sandy coast of what was recently German South-West Africa.

In the vicinity of the Vaal River diggings, the gravel varies in depth from a few inches to as many feet, and this "top" or superficial "wash," which is usually a loose, easily-worked gravel, held together with reddish loamy soil, often covers a distinct stratum of a different gravel; generally consisting of much larger stones, or boulders, often ten or twelve feet in depth, very much more compactly bound together, and usually of a greyish colour. In places this lower deposit becomes practically a conglomerate; the cementing matter being so hardened as to make it extremely difficult to break up. But whether "surface" gravel or "deep" gravel, the smaller water-worn pebbles that go to make up the diamond-bearing portion of it, are always, and everywhere, practically the same.

They are of agate, jasper, nodules of chalcedony, and other forms of silica, fragments of granite, and shale, and above all of banded ironstone, the latter providing the "bandtom" of the digger, an "indication" sought by him everywhere.

The method of searching for the diamonds is, with certain local and unimportant modifications, practically the same on all the diggings. Discarding the primitive and laborious process of hand-sieving and washing, which is rarely used now, except by the very poorest diggers, and which has very little chance of success, the usual procedure is as follows.

The would-be digger, having proved to the satisfaction of the Mining Commissioner and Diggers' Union, that he is a fit and proper person to hold a licence, and having obtained both that and a claims licence, pegs out a claim on the chosen spot, which must be part of a "proclaimed" area open to digging. The size of the claims varies somewhat, but they are usually 30 feet square, and the digger is by no means restricted to one; indeed, granted space be available, he can peg out as many as he cares to pay for, provided he works them within a specified time. He usually employs a gang of some six to a dozen natives; these "boys," as they are called, are usually Kaffirs, Xosas, or Basutos, who are to be obtained easily in the neighbourhood of the better known diggings, especially in the summer season. They are paid a wage which is periodically fixed by the "Diggers' Union," and is usually in the vicinity of £1 per week, in some cases being supplemented by a ration of "mealie-meal."

These men are, many of them, expert diggers, keen-eyed and not always honest, and usually require watching very closely. With picks and shovels the gang, under the supervision of the digger, excavate the gravel down to "bed-rock," which may be an actual bottom of shale, or a sandy stratum overlying another layer of gravel. The loosened gravel is "roughed" through screens of large mesh, which reject the larger stones. The boulders are thrown aside, and the resultant finer gravel is then sieved through a rocking machine called a "*bébé*," not as most people believe on account of its fancied resemblance to a cradle, but from the name of the Frenchman Bébé, whose invention it was.

This machine is a long, fine-meshed sieve, some six feet or so in length, by about two feet in width, slung by chains from a supporting framework, at a slant; the higher end being near the operator. At this upper part provision is made for a jumper sieve to rest, and the mesh of this sieve varies from half an inch to perhaps three-quarters. Into this sieve the previously "roughed" gravel is thrown, usually from a bucket, and the operator, holding the upper sieve firmly on the *bébé*, rocks the whole backwards and forwards. The finer gravel and sand fall through on to the inclined sieve of the *bébé*, and travel slowly down it, the sand falling through on its way, and only the fine gravel being shot from the lower end on to an evergrowing heap, which forms the "wash" for the next process, whilst the coarser particles remaining in the jumper, are, after a glance for a possible Cullinan, thrown aside to make place for the next bucketful. The next process, and one which only takes place periodically, and when a large amount of "wash" has been accumulated, is the actual washing by means of a rotary machine.

These machines consist of an iron pan, some four to six feet in diameter, and about a foot in depth, fixed in an extremely stout wooden framework, in which a series of spokes or arms, set with knives, are rotated by a crank. An inclined trough or "feed box" leads to the pan, and into this box the wash is fed, but not in a clean state. Instead, it is mixed with the necessary quantity of sand, or loam, and water,

into a mud, the consistency of which is a very vital factor in the ultimate recovery of any diamonds. Once the "wash" is in progress, the mixture is being constantly worked up in the upper end of the feed-box, and this work, which is an extremely dirty and unpleasant task, is usually carried on by one or two of the more experienced natives, who convert sand, water and gravel into a glorified mud-pie, as they feed it into the maw of the constantly rotating knives.

The result of keeping this mixture at a proper consistency is that once the machine is full, the lighter stones, kept in suspense by the constant rotary movement, run over the edge of the inner portion of the pan, and flow away in a sluggish stream of tailings only the heavier stones falling to the bottom. A little trap in the lower rim of the pan allows of the residue being occasionally tapped, and it is in this that the diamonds should be found. The final washing and sorting of this residue is an extremely important and delicate task, and is usually carried out by the digger himself. For this process a specially constructed sieve, known as a gravitating sieve, is used, it has an extremely rigid steel mesh, and the proper handling of it is the culminating test of the experienced digger.

Half filling it with the wash from the tap, he holds it quite level and firmly with both hands and rotates it just beneath the surface of the tubs of water, which form an essential part of his equipment, washing away the mud, until in the final water, when the gravel is perfectly clean, he finishes with a peculiar movement, only to be acquired by constant practice, and which has the effect of concentrating the heavier particles into the exact centre of the bottom of the sieve.

Then with an adroit movement he turns the sieve upside down, brings it down with a bang upon the sack-covered sorting table and lifts it, leaving the clean gravel exposed. If the sieve has been properly "thrown," as it is termed, the centre will show a well defined circle of concentrates much darker in colour than the bulk of the mass, and if the whole series of operations has been properly performed throughout, the diamond should be found amongst these comparatively few little stones.

These dark stones are principally composed of water-worn pebbles, of banded ironstone, already alluded to as "bandtoms," and of approximately the same specific gravity as the diamond, namely, 3.5.

It will thus be seen that the whole system is based upon gravitation, and the gradual elimination of the lighter stones; and although in addition to the rotary washing machines which I have described, there are other mechanical contrivances for washing and treating the gravel (notably the so-called "gravitator"), the principle is practically the same.

The sorting is usually carried out by the digger himself, who after a glance at the little circle of dark bandtoms, carefully scrapes and turns over the stones with a knife or other implement, and this process continues until the whole of the "wash" has passed through the machines and over the sorting table.

But the digger must not be disheartened if days and days of this laborious work ends in the "wash" proving a blank; he may find not only a heavy deposit of the accompanying bandtom, but may be cheered by the presence of garnet, olivine, and ilmenite (called "carbon" by the digger) in his concentrates, but the diamond itself may be absent. Indeed, not only his first "wash" may prove a blank, but the whole of his claim or claims; and yet within a few yards his neighbour may have struck a rich patch and be turning out a small fortune.

For nothing is so uncertain as diamond digging! The distribution of the stones in the gravel is so irregular that the finding of several near together affords no criterion as to the adjoining gravel, and there is no form of mining or digging in which the element of luck plays such an important part.

Small fortunes have been made in a few days by a new chum, have been in some cases picked up on the surface in the shape of a big and valuable stone, without a pick having been put in the claim; and the adjoining digger may be a man grown hoary at the work, who has never found enough to do more than barely pay for the poorest food—indeed he may be, and often is, half starved. But in the excitement of a big "find" in the vicinity, such as he are forgotten, and he indeed usually forgets his bad luck himself, buoyed up and encouraged by his neighbour's luck, which will be talked of long after he and the rank and file of unlucky ones have been forgotten.

But to return to the process of sorting. Not only has the digger carefully to watch and regulate every process down to the dumping of the sieve on the sorting table, but in the sorting itself he has to be extremely careful. His eye may be gladdened by the sight of a glittering stone, with its facets as bright as though fresh from the cutter, and fully exposed in the centre of the sieve—a triumph to his art as a gravitator—or it may be that the diamond, if present, is oxidised to such an extent as to be unrecognisable, except to the eye of an expert; or it may be a splint or a "mackel," or stone of unsymmetrical shape, and be thrown to the outside of the sieve, instead of being in the centre. The eye, tired with the constant attention of hour after hour of such work, can easily miss such stones as these, or in a moment of inattention they may be swept off the table with a handful of worthless gravel. Should, however, a find be made, the diamond, if at all oxidised, is placed in a bottle of hydro-fluoric acid and allowed to remain in it during the night, after which it will be found perfectly clean, though it is often by no means bright, but dull and cloudy, until it has ultimately passed through the hands of the cutter.

The digger is bound to keep a register of all diamonds found by him. He can sell them to a licensed diamond buyer on the spot, or may obtain a permit to export them and sell them overseas, or he may obtain a licence to hold them himself. He cannot even give them away without a permit, and in such cases the recipient must also obtain a licence to hold them.

But the digger is usually an impecunious being, and his finds are generally sold to a licensed diamond buyer on the spot. The buyers, as a rule, attend the principal diggings periodically, and their advent is generally signalled by the hoisting of a flag at the local hotel, or some such prominent rendezvous.

Here, rooms are set apart for their use, each individual buyer occupying a separate office, where the prospective seller may interview him in privacy. In some of the centres, a row of tiny huts, about the size of bathing boxes, and each well apart from its neighbour, serves the purpose of the visiting buyers, and on their arrival—usually in a body in motor cars—each little hut flies the pennant of some well-known dealer. And the digger can take his choice; he may if he chooses, go from one to another and try to obtain a better price for his treasure trove than the first dealer has offered him, but as a rule, so good a judge is the average buyer, and so fair is the price he offers, that little good is done by chaffering. And the regular digger soon becomes a customer of one particular firm of buyers. Of course there are exceptional cases, when extraordinarily fine stones have been found, or when the digger—as is occasionally the case—puts a fictitious value upon his hard-earned find. Or, again, there are cases when the buyer is anxious for a particular variety of stone to make up a parcel for Hatton Garden, and when he will pay an exceptional price for the class of stone he needs.

Of course all stones are weighed minutely, as a rule not only by the buyer, but by the digger himself; then again not only size, but colour, shape, and purity are factors in the value of the gems.

With the exception of so-called "fancy" stones, which are stones of a pronounced colour, and are very rare, the most highly-priced diamond is the so-called "blue-white;" a white stone of exceptional purity and with a suggestion of blue in its brilliant and liquid scintillescence. But these are seldom met with, and the digger is well content if his find is of the pure and colourless variety, known as the "Cape White." Many of the larger stones are slightly brownish or yellowish in tint, and these do not command the price of the white stones; though a brilliant canary yellow or an orange coloured stone would command a very high price, as a fancy stone.

The price of diamonds has naturally fluctuated considerably during the long life of the diggings: some twelve years since it was at its lowest ebb, and diggers could hardly dispose of their finds. During this period of depression small white stones of good quality only fetched about 25s. per carat, and the usual poverty of the diggings became terribly accentuated.

To-day, in common with every commodity, the price has gone up, and the same class of stone fetches about £5 or £6 per carat. Against this increase in price, however, there is, of course, the increased price of labour, etc. In addition a Government tax of 10 per cent. has been levied upon all stones registered; and this impost has hit the digger very hard. In the early days of the Diggings, the digger

was usually either an old gold prospector from any of the ends of the earth, or one of Kipling's "Legion that never was Listed," a younger son who had been sent out to the Colonies either to "make good" or disappear. Often, as far as the home folks were concerned, he did the latter, reappearing under an entirely different name on the diggings. There are some classical instances of this metamorphosis of young ne'er-do-wells of England, who, partly by luck on the diggings, and partly by push, have become magnates, plutocrats, and even Empire builders, in the country of their adoption. But the average digger has remained a poor man, indeed a very poor man. The possibilities open to the first-comers have long since disappeared. To-day, and indeed from the date of the amalgamation of the mines, his lot has been that of a labourer, a picker up of unconsidered trifles. In sight of him are the mineheads of De Beers, and though he may in his scramble for the crumbs that fall from the rich man's table, occasionally pick up not a crumb, but a plum, his chance of doing so is remote.

Then, again, there is usually a tendency amongst diggers who have struck a rich patch whilst working with a modest gang, immediately to launch out on a larger scale; and expensive machinery and a long wages bill often coincide with bad luck and a long blank, and the embryo "Diamond King" has to sell out at a ruinous cost and begin at the bottom again.

Another favourite ambition of the digger is to try his luck in the actual bed of the present river, which has been found in places to be extremely rich in diamonds. This can only be effected in the dry season when the river is at its lowest. Usually small syndicates are formed by a few of the lucky ones, who have made a little money, and as the river begins to fall, dams, or "breakwaters," as they are termed, are pushed out from the banks to enclose the chosen "pot-hole." This work is expensive, and has to be carried out rapidly, and often before it can be completed, a sudden flood from late rains up-country may have swept it away. Should, however, the enclosure be completed, the water is pumped out, and work carried on in the mud and ooze of the actual bed. Work of this description is not only unpleasant but often dangerous, as the river sometimes rises very rapidly, and in the attempt to save valuable machinery and gear from a rising flood, diggers and their natives have often been swept away and drowned. Still it is only fair to add that many of these "pot-holes" have proved extremely rich, and there are not a few successful men on the diggings who have taken ten or even twenty thousand pounds worth of stones out of a "breakwater" in the river bed during the few weeks the river has allowed them to work.

There are other methods of working the gravel besides those I have described, for instance, in places a very deep deposit on a rise may be quarried, or "open-faced," as it is termed, and the face thus exposed will often show a number of distinct strata of gravel, apparently deposited at different periods by recurring floods, or by the frequent changing of the river's course in the remote past.

Occasionally these deeper deposits are worked by means of shafts and drives, and the operation is then in the nature of mining.

As the result of good finds in "deep ground" of this nature, or where a very heavy deposit of gravel has been proved over a large area, small companies have from time to time been formed to work the gravel on a large scale; but few of these have been successful, and abandoned buildings, and rusted machinery and gear, can be seen in or near most of the diggings of to-day, a melancholy proof that the Vaal River diggings are a poor man's proposition, and never likely to pay dividends on a large capital. Better luck has attended the large companies, such as the New Vaal River Company, the Pniel Company, and others which have taken over very large areas of alluvial, and who sub-let claims to the digger, receiving a certain royalty on all finds. Certain of these companies have large pumping stations of their own, whence the water is conveyed in pipes to parts of the diggings remote from the river, doing away with the laborious process of "riding" water to the claims, which has to be resorted to on the ordinary Government ground.

Up to the outbreak of the war the population of the River Diggings had fluctuated between some 3,000 and 5,000 whites, and about three times that number of coloured men, but since the war, and the opening up of new fields, there has been an enormous influx of new diggers, many of them returned soldiers; indeed in some cases Government

assistance has been given to enable discharged men to make a start at this most precarious of livelihoods. The population is an ever-varying one, men out of employment staking their last few pounds on this gigantic "wheel of fortune," men who have come to try their luck for a week or two, and have remained a life-time, many indeed who have never had luck enough to enable them to get away! And in addition whole families of the "poor white" type, men, women, and children, uneducated, uncouth, and miserably poor, all engaged in the search for diamonds. Unfortunately, poor as is the general luck, the life is a fascinating one, and the saying "Once a digger, always a digger," is a very true one. For men who have had hard luck for years, even if they strike it rich at last, seldom go away; or if they do, drift back again in a very short time. Indeed, the life unfits a man for any other occupation.

In the foregoing description of the diggings I have chosen those of the Vaal River, as being the more extensive and better known, and fairly typical of all the others.

There are several smaller alluvial diggings, in the vicinity of the Premier Mine, north of Pretoria, at Mahura Muthla, near Kuruman, on the Harts River near Taungs, and notably on the Orange River near Aliwal North.

Those at Rouxville, near the latter place, have recently produced very fine diamonds, but the principal deposits there are in the hands of a company, and do not call for description here. Suffice to say that the company in question has been a success so far, and has proved that in spite of the failure of similar concerns on the River diggings to which I have alluded, under certain conditions a company or syndicate has a better chance than the individual digger.

Diamonds have also been found near the Orange River at several places down stream, below its juncture with the Vaal, and it may well be that the diggings will eventually spread in this direction. Indeed at the little known lower portion of this river, which near its mouth runs through an extremely wild and mountainous country, and where it forms the boundary between Little Namaqualand, Cape Province, and the newly-acquired territory recently known as German South-West Africa, there exist colossal terraces consisting of gravels identical with those of the diggings, but very much more highly concentrated. At a spot about fifty miles from the sea, where the river emerges from a series of narrow cañons which has penned it in for some hundreds of miles, and reaches open country again, these terraces have culminated in veritable hills, two or three hundred feet in height, and consisting of layer after layer of wonderful gravel.

Here the lower strata have become practically a conglomerate bound together with lime, presenting a precisely similar appearance to the very rich deposit recently found at Rouxville, fully eight hundred miles up stream and almost at the opposite side of South Africa.

At these huge beds diamonds have been picked up by the natives, but owing to their remoteness and difficulty of access, very little real attempt has been made to test them. Still, owing to the wonderful concentration, these deposits may very possibly some day prove a new and extremely rich source of the diamond.

I have laid particular stress upon these gravels, as they appear to form a connecting link with the diamondiferous deposits upstream, and those of the recently discovered deposits on the coast of what was recently German South-West Africa.

These deposits were first discovered in 1907, when the sands of Luderitzbucht, a little desolate seaport on the coast north of the mouth of the Orange, were found to be full of small glittering diamonds. At first the story was scoffed at, for there had been a German settlement there since 1884, and no one had ever heard or dreamed of diamonds being there. But diamonds they proved to be, and the deposit at Kolmans Kop, quite close to the settlement of Luderitzbucht, soon proved to be but one of many, indeed they have been proved to exist in varying quantities practically all up the coast from a little north of the Orange River well nigh to Walfish Bay.

The whole coast is a dreary and desolate one, bare sand dunes stretching for many miles inland; it is waterless, and with the exception of Luderitzbucht, was, at the time of the discovery, quite uninhabited indeed uninhabitable!

The diamonds, which are very small, and very brilliantly polished by the constant blowing sand, are found in a surface deposit of sand and grit. They are so uniform in size as to give the impression of

having been graded, as indeed they apparently have, by the action of both wind and water. And though the main deposits have been found at some small distance inland, rather than on the present beach, there is evidence that the coast line has been gradually rising, and that they came from the sea.

Farther transportation has been effected by the prevailing wind, which blows with great force during most of the year, and is the cause of the shifting sand dunes, which are a feature of the country, and which blows pebbles, grit, sand, and even diamonds impartially.

Of the many deposits located, by far the richest is at Pomona, south of Luderitzbucht, where the lucky first-comers literally filled their pockets with little diamonds. And everywhere along the coast, in close proximity to the diamonds, are found pebbles identical with those of the River Diggings I have described, smaller it is true, but having undoubtedly a common origin.

And the theory, held by many geologists is that the diamonds were, in common with gravel, at one time washed down the Orange and into the sea, whence the north-east setting currents have borne them along the coast, and the tides have deposited them where they are found to-day. Another theory is that they have been washed up from a pipe in the sea, but this would not account for the gravel, and it is also a fact worth noting that the size of the stones is larger near the southern extremity of the fields, near the Orange River, and becomes smaller and smaller at each successive field as one journeys north.

In any case, and whatever their origin, their discovery proved a godsend to the German Administration of the country, which had been a drain upon the Imperial German Government. Rules and regulations were hurriedly framed to control the new source of wealth, prospectors and would-be diggers flocked to Luderitzbucht, where at that time a condensing plant had to supply the only drinking water, except that obtained from the ships, and where conditions were as unfavourable either for prospecting or digging as can well be imagined.

In spite of this, and at risk of their lives, men spread up and down the coast, and extraordinary finds were made—many of them to be confiscated by the German officials; and within a month or so of the first finds, the Deutscher Bank in Luderitzbucht had an enamelled bucket three parts full of the precious stones, which had been placed in their keeping pending a decision as to the rightful owners.

To add to the general confusion many claimants for certain valuable portions of the coast now put in an appearance, their claims being generally based upon old concessions granted by the natives prior to the taking over of the land by the German Government; and many such claims had never been registered, as the land had always been considered worthless.

In addition to these claimants, several large companies laid claim to the land, others dug up long forgotten clauses in their charters which gave them a right to "minerals," and in some cases even specified "precious stones should such be found," and in the midst of this confusion new companies were continually being formed. So for a time chaos reigned, during whch the licensed prospector was at a great disadvantage, since he never quite knew in pegging a claim whether his title to it would in the end hold good.

And he, as had been the case in Kimberley nearly forty years earlier, gradually disappeared, giving place to various companies, amongst which the better-known, such as Kolmans Kop, and Pomona, had proved, when war broke out in 1914, highly productive. The stones are very small, ranging from one quarter to an eighth of a carat, but are of good quality, and up to August of that year about 5,400,000 carats had been extracted, of an approximate value of nine and a quarter millions sterling. The output was strictly controlled by the German Government, and the sales limited to a little over a million carats annually.

Upon the British occupation of the country in 1915, all prospecting and working for diamonds was forbidden, but at a later date work on a limited scale was allowed. Meanwhile the occupation had led to thousands of Union troops being stationed on or near the actual fields, and many of these men planned to return when—as was believed to be likely to happen—the country should be thrown open to prospecting. They, and many a river digger looking for more favoured fields, were however, doomed to disappointment, for although upon the assumption of the mandate of the country by the Union Government, the bulk of the new territory was thrown open, the coastal

belt containing the diamond fields remained forbidden ground.

And to-day the strip of country stretching from the Orange River to the 26th degree of latitude, and from the coast for 100 kilometres inland, including all the richer mines, has passed under the control of a British combine, who will regulate the output and generally manage diamond matters in South-West Africa.

And although this decision has been an extremely sore point with individual diggers, it is probably the best thing that could have happened. For the country, barren, inhospitable, and waterless, is not fit for the individual with small means, and the indiscriminate granting of licences in such a region would probably have led to a great amount of hardship to the many, and riches but to the few.

In conclusion I may point out that, although an ardent digger myself, and by no means a pessimist, I do not think that anyone should be encouraged to take up the life as long as he can obtain a livelihood otherwise. Certainly he should never dream of migrating to South Africa for the purpose of doing so. Unless he be exceptionally lucky, the average digging open to him to-day, is likely to swallow up all his little capital, and leave him worse off than he would have been in England. On the other hand, it has been abundantly proved of late that the distribution of the diamond is far more widespread than has been imagined, and systematic prospecting may well disclose new fields of far greater richness than those known at present. The startling discoveries in the sands of Luderitzbucht in 1907, may well find their parallel elsewhere; indeed the extraordinary richness of the newly-discovered fields in Akim on the Gold Coast shows that diamonds are by no means even confined to the regions I have described.

DISCUSSION.

THE CHAIRMAN (Major Sir Humphrey Leggett, R.E., D.S.O.), said the author had given a most valuable account of what must be one of the most adventurous and dangerous occupations of the world. His description recalled the poet's words, "Hope springs eternal in the human breast," and showed that man would undertake almost any hardship in the hope of reward. It must have been a surprise, he thought, to some of the audience, to hear how many men were engaged in the industry, and that, during a time of rush, the numbers at a township rose by many thousands. The thought had occurred to him that, in the coming and going across unknown land, although but few people might reap the reward for themselves, not only were most valuable discoveries made in connection with diamonds, but other unsought for discoveries resulted. This adventurous groping also had the effect of bringing to the knowledge of the natives of the districts explored, what a white man and white civilisation really were. The behaviour of the white man in out-of-the-way parts was undoubtedly an example for good. The old lurid stories of what occurred in the mining camps were things of the past. Englishmen in the outlying portions of the Empire behaved as Englishmen should do. It was not always borne in mind how much international politics had been affected by exploration and search for diamonds. Sir Harry Wilson, who was present, would remember that in the old days the boundary between the British territory and the old Dutch Republic turned on a question of where the diamond deposits lay. An extraordinary windfall had come to the British Empire in the acquisition of South-West Africa, and there was a possibility of considerable wealth being extracted from the country by systematic company or individual endeavour. He believed it was a fact that 95 per cent. of the diamonds of the world were produced within the British Empire, and that had a considerable influence on international exchanges—for example, it would be a serious thing if the people of England wished to buy diamonds and had to purchase them from the United States, instead of the business being in the reverse direction. It seemed to him, however, that the discoveries which were being made day by day by adventurous people were in need of regulation. He understood from the author that the greater part of South-West Africa was now forbidden to the individual, and he thought the author had done wisely in trying to dissuade individuals from adopting the life of a digger. There could be no doubt that the alluvial diamond industry was of great importance to the welfare of South Africa, and probably other portions of the British Empire as well, and that, under regulation and expert guidance, the end of the discoveries of such wealth was nowhere near.

PROFESSOR ERNEST H. L. SCHWARZ, F.G.S. (Rhodes University College, Grahamstown), said the author had very rightly indicated that geologists did not know very much about the origin of diamonds in alluvial deposits. The subject was an exceedingly difficult one. He remembered being shown at the head office of the De Beers Mine in Kimberley a beautiful octahedron over an inch in diameter, which the experts there said undoubtedly came out of one of the mines in Kimberley, but a digger in the river diggings had brought it in to sell.

The detectives at Kimberley identified it as a mine stone, but the digger declared emphatically that it was a diamond from the river diggings. The detectives eventually went out to the claim and dug the gravel themselves, from which they obtained the same kind of diamonds. It was difficult to get over evidence of that sort. He believed the author was correct in saying that the river stones were different from those that were obtained from the mines, but cases occurred in which it was difficult to make such a definite statement. It was not known where the alluvial diamonds came from. For some years past he had been getting washings from sandstones of a considerable age, and he very often found diamond splinters in the concentrates, and diamonds were also obtained from the Witwatersrand conglomerate. It was a possible theory that the diamonds found along the Vaal and Orange Rivers did not come from the mines at all, but from a covering of triassic sandstone. The sand might have blown away and the heavy concentrates been washed out of the rivers, the gravels thus being obtained. He endorsed the author's advice that nobody should rush out to South Africa and start diamond digging.

Sir Harry Wilson, K.C.M.G., K.B.E., in dealing with the administrative aspect of the river diggings, said that when a large shifting population suddenly assembled in a place in which there was no provision for them, naturally the Government of the country had to take certain measures to provide them with the necessaries of organised life. Such instances occurred on the Vaal River on the borders of the Orange River Colony. He remembered on one occasion travelling to see the diggings not far from Christiana, where there was a large collection of river diggers, and Lady Wilson and himself had two or three very interesting days in visiting the whole community. On that occasion diggings were going on in the bed of the River Vaal, some of them of a very elaborate kind. There were also ordinary diggings in various parts of the gravel, and miniature underground mines were being worked in other places by small syndicates of diggers. He desired to endorse what the author had said about the exceedingly law-abiding character of the population, which, coming as it did from all parts of the Union, was naturally composed of very diverse elements. No trouble was ever experienced with the river diggers, and he thought it might be said that the Administration did their best in the old Crown Colony days to provide them with certain necessaries for instance, schools, and inspectors and police. He thought the discovery of diamonds near Rouxville must be quite recent, as he did not remember diamonds being found there during his term of office in South Africa. He would very much like to know with what river system it was connected; he presumed it was the Orange River.

Mr. Cornell said that all the diggings were in the old bed of the Orange River.

Sir Harry Wilson, continuing, said that two very remarkable discoveries of diamonds occurred while he was in the country, one, the Roberts Victor Mine, and the other the Voerspoed Mine, in the neighbourhood of Kroonstad. There was an interesting story in connection with the first mine. An old Cape farmer of the Eastern Province named Roberts continually dreamed that he was going to find a diamond mine, and so convinced was he that the dream would prove to be true that he sold up his property in the Eastern Province, and bought a farm in the neighbourhood of Boshof in the Orange Free States. Instead of farming it, he set to work to try and find a diamond mine, but he did not discover one. He eventually died, but in his will he told his executors that they were to carry on the work he had begun, because he was quite certain there was a mine on the property. One of his executors, now Senator Sir John Fraser, employed the best expert he could obtain to carry on the work, and within three or four weeks of the date of his employment one of the richest mines in South Africa was discovered within a very few yards from where Mr. Roberts had been working. Mrs. Roberts leased her interest in the mine for a comparatively short period for a very large sum of money.

Dr. M. Horn (Councillor of State, Belgium) said that although diamonds were widely distributed in the Belgian Congo, the only exploitable deposits so far found were the alluvial diamond fields of the Kasai district in the vicinity of the River Tshikapa. These fields were discovered in 1907, and washings commenced in 1913. The efforts of the Administration were first of all devoted to providing this outlying part of the Colony with means of communication. A road about 95 miles long suitable for motor lorries and oxen-waggons was now leading from Djoko-Punda, the navigable terminus of the Kasai River, to the diamond fields. The output had risen from 50,000 carats in 1915 to 215,000 carats in 1919. The value of the output of 1920 was estimated at £600,000. On the average, the stones were small, but of good quality; the largest stone yet found weighed about 32 carats. The number of natives at present employed on the "placers" was about 8,000, whilst several thousand more were finding employment in providing housing for the white staff and Government officials, road-making and other constructional work. The *Société Internationale Forestière et Minière*, a little over half of the capital of which the Belgian Congo Government owned, the remainder being divided equally between some Belgian groups and the American banking

group of Guggenheim, controlled the undertaking. In view of the rapidly growing requirements of the district, the import trade of the country would be considerably developed, and it would prove, he hoped, a new market for British industry, and at the same time prove of advantage to the owners of the mines, the natives and the Congo Treasury.

Mr. J. L. Williams said that the discovery of diamonds in Eastern Akim, to which the Lecturer had referred, was made by the Director of Geology to the Government, who, in the course of his peregrinations for the purpose of building up the geological data of the country, panned some gravels which he thought might contain gold, and found diamonds in addition to gold; and as a result of several days' investigation, discovered diamonds in ten different places. Operations had been conducted in various directions, and diamonds had been obtained with a considerable amount of ease, and an alluvial deposit or a shedding or detrition undoubtedly existed. As the Lecturer had seen the diamonds that had come from it, he would be glad to know whether their appearance indicated the probability of the source being more easily discovered than in South Africa. He believed that at Kimberley the surface discovery consisted of high-grade alluvial deposits which afterwards turned out to be detrition from pipes in the locality. Indications were that plenty of diamonds existed in Eastern Akim, and if those concerned with the development could be informed that the appearance of the stones found there indicated something different from those found in Souh Africa, it would be greatly appreciated.

Mr. W. S. Lockhart, M.Inst.C.E., said he gathered from the paper that the diamonds in German South-West Africa were mostly of very small size, and it would be interesting to know if any large diamonds had been found, and if so, up to what size. He also desired to ask whether, if operations were carried on further away from the coast, stones of a bigger weight might be expected to be found. Did the character of the gravel in German South-West Africa coincide with the river digging gravel, and were the diamonds like those obtained from the river diggings and the mines?

Rear-Admiral J. de Courcy Hamilton, M.V.O., in proposing a vote of thanks to Mr. Connell for his excellent paper and lantern views, said he was glad to know that the diamond-cutting industry had now been introduced into this country and gave employment to a very large number of ex-Service men. Although diamonds were worn mainly by ladies, he imagined from the slides that had been shown that there were no ladies on the diamond fields at all, so at any rate, there was one industry which was left for men exclusively. It was a very fortunate thing that Providence had placed at the disposal of mankind rare metals and stones which were essential to the making of accurate watches, scales and compasses.

Mr. Walter Reid, F.I.C., F.C.S., in seconding the motion, said that if anybody desired to read a book which indicated that Britishers were not yet played out, they should read Mr. Cornell's "The Glamour of Prospecting," which was one of the finest works of the kind that had ever been written. As an old prospector in Brazil, he desired to state that the question of the origin of the gravel in which diamonds were found was of the greatest importance to those connected with the industry. The reference made in the paper to the glacial origin was, he thought, quite correct. With regard to the question of the whole of the industry being absorbed by one big company, while that company might make a profit out of the undertaking, that was not the way to develop the industry. The statement had been made that in what was formerly German South-West Africa nobody might dig or prospect for diamonds. He thought that was shutting down an industry which might become extremely valuable to the country. The question was also of importance to the diamond industry itself. An industry was not necessarily improved by raising the prices, and it must also not be forgotten that some very clever chemists were on the track of the diamond producer. He knew what had been done in connection with the production of diamonds artificially, and he had made artificial diamonds himself, using carbide as the raw material. He had been much struck by a notice which appeared in the Press that the Nobel Dynamite Company of Hamburg, were producing diamonds artificially and had made many thousand carats. That might or might not be true, but the artificial diamond industry might grow as the artificial indigo industry grew. Diamond producers ought to bear in mind that the higher they kept the values the better it paid other people to produce diamonds artificially.

The Chairman, before putting the motion, said it had been hoped that Sir Bernard Oppenheimer, who had just been honoured with a Baronetcy in recognition of his services in introducing the diamond-cutting industry into this country, and thereby given employment to a large number of ex-Service men, would have been present at the meeting. He was sure it was the desire of those present that they should record in an informal way their congratulations to Sir Bernard Oppenheimer on the great honour which had been conferred upon him.

The motion was carried unanimously.

Mr. Cornell, in reply, said the reference Professor Schwarz had made to stones being found on the Vaal River, which the experts declared to be mine stones, although they were not, was typical of what had happened on more than one occasion, but he maintained the statement he had made in the paper was correct—that there was a perceptible difference between diamonds found on the diggings and those found in the mines. One of the former experts of the De Beers Company possessed an almost uncanny sense of the origin of diamonds. He could not only differentiate between diamonds from the diggings but between the diamonds from various mines. He agreed with Sir Harry Wilson's statement that the Administration was to be commended for the way in which it had handled the populations in the diamond districts, particularly in times of rush, when an enormous population would congregate at a particular place within a very short time. He had been much interested in what Dr. Horn had said with regard to the Belgian Congo. Data had not been obtainable in regard to Belgian Congo diamonds, and he would very much like to get as much information on the subject as possible. It was not easy to dogmatise with regard to the Akim diamonds after merely seeing them in a parcel, but he had formed the opinion that they were not alluvial diamonds, as the term was understood in South Africa. They must have been found within a very short distance of some plug, vent or form of matrix in the immediate locality. None of the detritus which had been shown him could be called gravel, and, moreover, the diamonds were of quite a different kind from those found in the deposits of South Africa. The stones found in German South-West Africa were very small; in fact they appeared almost to have been graded because of their extraordinary similarity one to the other, which was not a feature of the stones found on the Vaal River or any of the other diggings in South Africa. An entrancing feature of the diggings proper was that, while one plot might produce a tiny stone, the next plot might produce one the size of a walnut. The diamonds were irregularly distributed, and very irregular in size, varying from hundreds of carats down to minute stones. The largest stones found at Pomona ranged from four to six to the carat, and were all of excellent quality. Those found at Kolmans Kop were smaller still, and as one went farther north so the size of the stones decreased. It was said that one stone had been found at Pomona which weighed 20 odd carats, but it had never been proved to have come from there. The 5,000,000 carats of diamonds that had been produced in German South-West Africa had scarcely produced a dozen stones of a carat weight each. The diamonds were not found in what would be termed gravel, but grit, which had been ground down to the same size as the diamonds found in conjunction with them. With regard to Mr. Lockhart's question as to whether stones of a larger size would be found farther away from the coast, inasmuch as the grading appeared to have taken place by the action of the sea and the wind, and as it was a country in which the whole surface of the ground walked in a storm, it might very conceivably be the case that other deposits of larger stones would eventually be located farther inland. It was not correct, as Admiral Hamilton had inferred, that there were no ladies on the diggings. As a matter of fact, quite a number existed there, and also children, many of the diggers having their wives and families with them. He thought Mr. Walter Reid had missed the point in connection with his remarks that all the diamonds in German South-West Africa were in the hands of a company. He quite agreed that freedom of prospecting was the only possible thing for open countries, but he desired to emphasise that most of German South-West Africa was extremely difficult country. Moreover, not the whole of it was forbidden to the prospector, but only the strip 100 kilometres inland from the sea from the mouth of the river up to the 26th degree. Personally, he was a long way from saying that synthetic diamonds were impossible, but he did not think the average diamond company feared their advent.

The meeting then terminated.

FRUIT GROWING INDUSTRY FOR TRINIDAD.

The Committee of the Agricultural Society of Trinidad and Tobago that was appointed to inquire into the possibility of establishing a fruit industry in that colony on a business basis has recommended that, for the purpose of an export trade, attention should at first be directed principally to oranges, grapefruit and mangoes.

With regard to possible markets, information was elicited on inquiry from Canada, the United States, and some of the British West Indian Colonies. Canada, it was stated, consumes a rapidly increasing amount of tropical fruit, which is supplied very largely through the United States. In connection with export, both to Canada and to the United States, mention was made of the complaint of a New York firm to the effect that West Indian shippers do not seem to realise the importance of uniform colour and packing, and that failure to attend to these requirements created an unfavourable impression.

According to a report by the U.S. Consul in Trinidad, it is now proposed to organise the local fruit industry in such a way that it will appeal to planters throughout the colony, who can have assurance that their fruit will be purchased locally by shippers when ready for the market, provided they follow instructions regarding picking, preparing and packing.

EGG INDUSTRY OF TIENTSIN.

The prepared-egg in the Tientsin district was started several years ago and was in a flourishing condition up to 1918, when it was severely affected by the food laws and war restrictions of various importing countries, particularly the United States. In 1917 over 5,000,000 pounds of egg albumen and yolk, dried and moist, were exported, and in 1918 only 2,000,000 pounds. On the other hand exports of fresh eggs increased in 1918 by 472,000 dozens over that of 1917. The total export of eggs in 1918 amounted to 5,344,000 dozens.

When the dried egg industry was first promoted in the Far East, all plants were equipped with trays and drums for drying purposes made of zinc, which resulted in a metal content in the product. A new method was then introduced by means of "spraying," or blowing the egg in a fine spray into a heated chamber. The resulting product, reports the U.S. Consul-General at Tientsin, is free from metal, and the various egg-drying plants in the interior, which are largely in the hands of Chinese, are gradually converting their establishments into spray plants.

There is, however, a greater demand for moist eggs not only in Europe, but also in America, where the consumer does not take kindly to powdered albumen. Although there is in America a good demand for the powdered yolk, local manufacturers cannot be expected to sell the yolk without at the same time disposing of the albumen. The result has been an increase in the exportation of moist albumen and moist yolk and of fresh eggs. Frozen eggs are not shipped from Tientsin as yet, owing to the fact that no refrigerator steamers ply to and from that port. An American company is building a plant in Tientsin and will soon have a steamer with cold-storage equipment operating between there and San Francisco for the transportation of frozen meat and eggs.

There are 13 albumen factories in the district around Tientsin, 11 of which are Chinese and three foreign. The Chinese concerns, with one exception, are of the usual type of egg-product factory and have no machines; but the foreign companies, which are managed by Americans and French, have installed American drying machinery for the manufacture of their products. These companies have passed the purely experimental stage and are doing well.

MEETINGS FOR THE ENSUING WEEK.*

MONDAY, JAN. 24.. Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. F. C. Cornell, "The Lower Reaches of the Orange River."
East India Association, 3, Victoria Street, Westminster, S.W., 3.30 p.m. Dr. C. Webb-Johnson, "Medicine in India."

TUESDAY, JAN. 25.. Sociological Society, 65, Belgrave Road, S.W., 8.15 p.m., Mr. H. J. Laski, M.A., "The Prospects of Parliamentary Government."
Automobile Engineers, Institution of, 7, The Quadrant, Coventry, 7.45 p.m., Mr. J. T. Hacking, "Accessibility."
Royal Institution, Albemarle Street, W., 3 p.m. Col. Sir Gerald Lennox-Conyngham, "The Progress of Geodesy in India." (Lecture II.)
Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m. 1. Discussion on Prof. T. B. Abell's paper, "Reinforced Concrete for Ship-Construction." 2. Mr. G. Ellson, "Cannon Street Bridge Strengthening." 3. Mr. F. W. A. Handman, "Reconstruction of a Viaduct."
Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Anniversary Meeting.
Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Mr. G. Howell, "Petroleum Resources of the British Empire."
Electrical Engineers, Institution of (N. Midland Centre), Hotel Metropole, Leeds, 7 p.m. Mr. W. B. Woodhouse, "The Distribution of Electricity."

WEDNESDAY, JAN. 26... Launderers, National Federation of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m.
Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. Students' Meeting. Mr. F. E. Wentworth-Sheilds ("Vernon-Harcourt" Lecture), "The Lay-out and Equipment of Docks."
United Service Institution, Whitehall, S.W., 5.30 p.m. Commander R. N. Suter, "Naval Costume, Past and Present."

THURSDAY, JAN. 27... Flour Milling Employers' Federation, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 10 a.m.
Wireless Society of London, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m.
Royal Society, Burlington House, W., 4.30 p.m.
Antiquaries, Society of, Burlington House, W., 8.30 p.m.
Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Mr. G. A. Juhlin, "Temperature Limits of Large Alternators."
Royal Institution, Albemarle Street, W., 3 p.m. Dr. A. Harden, "Biochemistry (Vitamines)." (Lecture II.)
Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr. J. A. Howe, "Geology in Relation to Building Stones."

FRIDAY, JAN. 28.. Metals, Institute of (Sheffield Section). Mappin Hall, The University, Sheffield, 7.30 p.m. Prof. C. H. Desch, "60:40 Brass."
Royal Institution, Albemarle Street, W., 9 p.m. Sir James Dewar, "Cloudland Studies."
North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Westgate Road, Newcastle-on-Tyne, 7.30 p.m. Mr. W. A. White, "Fuel Oil."
Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

SATURDAY, JAN. 29.. Chromatics, International College of, Caxton Hall, Westminster, 3.15 p.m. Mr. E. K. Robinson, "Colour as the Expression of Life."
Royal Institution, Albemarle Street, W., 3 p.m. Dr. P. C. Buck, "The Madrigal." (Lecture II.)

* For Meetings of the Royal Society of Arts see page 135.

SETS OF JOURNALS WANTED.—The offer of a set of *Journals* for the last twenty years, which was made in the issue of January 7th, has produced several applications from public institutions. If any Fellow of the Society possesses a fairly complete set, bound or unbound, which he is willing to present to a public institution or library, where it will be considered of great value, he is requested to communicate with the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 31st, at 8 p.m. (Howard Lecture). ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E., "Aero Engines." (Lecture III.)

TUESDAY, FEBRUARY 1st, at 4.30 p.m. (Colonial Section). G. C. CREELMAN, LL.D., B.S.A., Agent-General for Ontario, formerly Commissioner of Agriculture and President, Ontario Agricultural College, "Modern Agriculture with special reference to Progress in Canada." SIR DANIEL HALL, K.C.B., F.R.S., Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture, in the Chair.

WEDNESDAY, FEBRUARY 2nd, at 8 p.m. (Ordinary Meeting.) A. F. BAILLIE, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World." PROFESSOR SIR JOHN CADMAN, K.C.M.G., D.Sc., in the Chair.

Further particulars of the Society's meetings will be found at the end of this number.

PETER LE NEVE FOSTER PRIZE.

Mr. Reginald Le Neve Foster has presented the Society with a donation of £140 for the purpose of founding a prize in commemoration of his father, Mr. Peter Le Neve Foster, who was Secretary of the Society from 1853 to 1879.

The Council have determined to offer the Prize for a Paper on "The Mineral Resources of China."

The Prize will consist of a sum of £10 and the Society's Silver Medal.

The Paper for which the Prize is awarded will be read at one of the Ordinary Meetings of the Society.

Intending competitors should send in their Papers not later than December 31st, 1921, to the Secretary of the Royal Society of Arts, John Street, Adelphi, London, W.C. 2.

The Paper must be type-written. It may be sent in under the Author's name, or under a motto, accompanied by a sealed envelope enclosing the name, as preferred.

The Judges will be appointed by the Council.

The Council reserve the right of withholding the prize or of awarding a smaller prize or smaller prizes, if in the opinion of the judges nothing deserving the full award is sent in.

HOWARD LECTURE.

On Monday evening, January 24th, Mr. Alan E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E., delivered the second lecture of his course on "Aero Engines."

The lectures will be published in the *Journal* during the summer recess.

SEVENTH ORDINARY MEETING.

WEDNESDAY, JANUARY 19th, 1921; THE RIGHT HON. LORD ASKWITH, K.C.B., K.C., D.C.L., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Birkett, Thomas, Wigston Hall, near Leicester.
Davenport, Dr. Isaah, Paris, France.
Harding, William Gerald, Windsor.
Napier, Archibald Scott, M.Inst.C.E., London.
Rollins, Dr. Herbert, Boston, Mass., U.S.A.

The following candidates were balloted for and duly elected Fellows of the Society:—

Aspden, Ralph L., Chorley, Lancs.
Braddock, Geoffrey Frank, London.
Creed, Frederick George, Croydon.
Cuthbert, The Hon. Sydney, Belize, British Honduras.
Mackey, Prof. William Thompson, Ph.D., Washington, D.C., U.S.A.
Pittard, Major William Ebenezer, Southampton.
Pye, James, Burton-on-Trent.
Selson, Henry Maxwell, Gerrard's Cross, Bucks.

Staiti, Henry T., Houston, Texas, U.S.A.
Tyler, Alfred C., London.
van Santvoord, Seymour, Troy, New York, U.S.A.
Williams, Thomas Elson, Watford.

A Paper on "The Future of Industrial Management" was read by MR. F. M. LAWSON, Assoc.M.Inst.C.E.

The paper and discussion will be published in a subsequent issue of the *Journal.*

INDIAN SECTION.

A meeting of the Indian Section Committee was held on Wednesday, January 19th. Present :—Sir Charles S. Bayley, G.C.I.E., K.C.S.I. (Chairman of the Indian Section) in the chair, Sir Charles Armstrong, William Coldstream, B.A., Laurence Currie, M.A., J.P., Sir H. Evan M. James, K.C.I.E., C.S.I., Major-General Beresford Lovett, C.B., C.S.I., Sir Charles C. McLeod, N.C.Sen., O.B.E., and Colonel Sir Charles Edward Yate, Bt., C.S.I., C.M.G., M.P., with G. K. Menzies, M.A. (Secretary of the Society) and S. Digby, C.I.E. (Secretary of the Indian and Colonial Sections).

FRIDAY, JANUARY 21st; SIR CLAUDE H. A. HILL, K.C.S.I., C.I.E., in the Chair. A paper on "Indian Timbers" was read by MR. R. S. TROUP, M.A., C.I.E., Indian Forest Service, Professor of Forestry in the University of Oxford.

The paper and discussion will be published in a subsequent number of the *Journal.*

LIST OF FELLOWS

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

CASES FOR JOURNALS.

At the request of several Fellows of the Society, cases have been made for keeping the current numbers of the *Journal.* They are in red buckram, and will hold the issues for a complete year. They may be obtained, post free, for 7*s.* 6*d.* each, on application to the Secretary.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s.* each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

ALDRED LECTURE.

WEDNESDAY, JANUARY 12TH, 1921.

MR. W. L. HICHENS (Chairman, Messrs. Cammell, Laird & Co., Ltd.), in the chair

THE CHAIRMAN, in introducing the lecturer, said that Dr. Myers was known to all as one of the most eminent psychological experts of the day. To many he was best known on account of the brilliant work that he had done in connection with the application of the principles of psychology to industry. Dr. Myers was a member of the Industrial Fatigue Research Board, and had also done very important work in connection with the National Institute of Industrial Psychology, which really owed its existence to him more than to anybody else. A very important future lay before that Institute, because there was a great deal that could and ought to be done in applying the principles of psychology in a practical way to industry.

The following paper was then read :—

INDUSTRIAL FATIGUE.

By CHARLES S. MYERS, M.D., Sc.D., F.R.S., Director of the Psychological Laboratory, and Lecturer in Experimental Psychology, University of Cambridge.

We have no satisfactory definition and no satisfactory test of fatigue. If we define fatigue by its effects, by the diminished quality and quantity of work done—we confuse it with mere boredom, and we neglect the fact that in certain conditions fatigue may temporarily be accompanied by increased output, owing to deficient higher control and to abnormal nervous excitement, just as may occur in the early stages of alcoholic intoxication. For these reasons, output is not a really satisfactory criterion of fatigue. Yet at present no better criterion is available. Various fatigue tests have been proposed and tried, but none of them can be said to be really adequate for industrial application. These tests may be classified under four headings—(i) muscular, (ii) mental, (iii) nervous, (iv) circulatory and respiratory.

For the muscular tests, the dynamometer and the ergograph have been employed. The dynamometer registers the maximum grasp or pull of which the subject is at any moment capable. The ergograph records the extent to which a single (finger) joint can be flexed, when

it is being rhythmically flexed and extended against the resistance of a given weight. The ergogram, or muscular work curve, thus obtained, shows the height and number of these periodic flexions and extensions until a condition of exhaustion is reached in which the subject is wholly powerless to bend the joint.

The chief mental tests applied to the measurement of fatigue have been tasks of addition, letter-erasing and dot-hitting. In the addition tests, successive pairs of numbers are added, in the letter-erasing test every example of a prescribed letter has to be marked in a piece of print and the amount of work done is later measured in the form of a mental work curve, minute by minute, the subject having made a mark on his paper indicating the place he has reached each time a signal sounds at the close of each minute. In McDougall's dotting test, a series of small circles, irregularly printed on a long strip of paper, rapidly passes before the eye of the subject as in the tape telegraphic machine. As these circles pass, he has to dot the central point of each with his pencil, and his efficiency is measured by the number of circles he misses or fails to dot correctly, and by the number he has dotted correctly in a given time.

Such simple laboratory tests may appear to the unscientifically minded quite useless for the determination of efficiency in ordinary life; but in point of fact, they have proved of enormous value, especially in enabling us to approach the study of industrial fatigue with due regard for the complexity of the subject and for its surrounding pitfalls.

Investigations are still in progress in regard to other possible mental tests, and also in regard to variations in reflex action, blood pressure, pulse and respiratory gaseous exchange, as indicators of fatigue. But it is not yet possible to speak definitely as to the promise of success of the latter tests. Their value consists in their lying beyond the voluntary control of the subject, their disadvantage in their being subject to emotional changes in him. Remove a worker from his job, and confront him with instruments for testing his blood pressure or his reflex action; he may suffer alarm at the apparatus, annoyance at being disturbed in his work, or increased or diminished interest, any of which may obscure the evidence of existing fatigue.

The mental work curve has been analysed to show the presence and effect of five different factors—fatigue, practice, incitement, settlement and spurt. These five factors, carefully studied in the laboratory by means of the mental tests above described, have been found of great importance in the industrial work curve—the curve of hourly or daily output by the worker. The mental work curve, in the case of an inexpert subject, will often fail to shew signs of fatigue, because fatigue is masked by the varying amount of practice that continues, and comparison between successive periods of time is thus rendered impossible. With increasing experience, the practice effects become less, and the fatigue effect would be expected to manifest itself earlier and more markedly. But with increasing experience the subject also begins to learn less fatiguing and more economical methods of working; and this is especially the case in industrial work, in which various methods are possible and where at first many useless movements and needless muscles are employed.

Practice effects are invariably enormous at first, and finally become minute. Conversely, when a subject loses a few days' practice, the effects are hardly recognisable at first, but become more and more so later. As a celebrated pianist once observed—"if I miss a day's practice, *I* notice the difference; if I miss two days' practice, *my wife* notices the difference; if I miss three days' practice, *the public* notices the difference."

In industrial life, a very small disturbance in the methods of work is found to bring about a striking loss in the practice previously acquired. Two investigators under the Industrial Fatigue Research Board, Mr. S. Wyatt and Mr. H. C. Weston,* recently endeavoured to measure the fatigue occurring in the process of bobbin-winding in the cotton industry. Each girl has charge of one hundred pairs of spindles, and her work consists chiefly in walking past them and "piecing" (knotting together) the ends of yarn from the smaller ring bobbins from which the yarn is wound on to the larger warp bobbins, to any one of which the yarn of several ring bobbins

* "A Performance Test under Industrial Conditions." British Journal of Psychology. 1920. Vol. X., Pt. 4, pp. 293-309.

is transferred. These investigators confronted each girl with fifty pairs of spindles, and estimated the time taken for her to knot together their fifty pairs of ends. The main difference between the conditions of this test and the normal arrangement of the operative's work consisted in the quicker and more regular process of knotting. In her ordinary work, the girl passed up and down before the spindles under her charge and pieced the ends as they needed piecing. In the test she had to piece them one after another, as speedily as possible. But in the test the practice effects were so great and interfered so markedly with the fatigue effects that it proved quite useless as a fatigue test until after three weeks' experience twice daily; even then there was still considerable practice effect noticeable.

Take a person away from his work for a few minutes and then let him return to it. As is well known, he needs a short time to "get going" again. What is lost is clearly something different from the practice which comes from experience. The effects of such a brief respite may be compared to the growing cold of an engine allowed to rest. Man likewise needs "warming up" to his work. The inefficiency that occurs after such a brief period of rest is due to the loss of what has been technically termed "incitement." Its presence was first investigated in the analysis of the work curve after rest pauses in the laboratory; its presence after an interruption in industrial work is well known.

When work is resumed after a longer rest, there occurs not only the loss of incitement (*i.e.*, the need for "warming up") not only the loss of practice (*i.e.*, the decrease of manipulative or mental skill), but also the loss of a further factor which may be usefully distinguished as "settlement." "Settlement," as its name implies, consists in settling down to the environment and conditions of the work, *e.g.*, in becoming adapted to, and so coming to neglect, disturbing noises and other distractions, or in becoming attuned to the sequences and rhythm of movements or of mental operations which he has to carry out. The absence of "settlement" is responsible for the well-known "Monday morning effect." It occurs among those who have spent the week-end restfully as well in those who have spent it in dissipation. The absence of settlement is also evident after a holiday.

Thus far we have considered the factors of fatigue, practice, incitement and settlement present in the industrial work curve. The fifth and last factor we have to consider is that of "spurt." We must bear in mind that no one, even with the best will in the world, puts forth his maximal power of work. Our muscular or mental capacity seems always to be held in restraint; our reserve powers are inhibited by higher control. In certain circumstances this higher control is itself fatigued or inhibited. Occasionally, therefore, in conditions of fatigue, an increased amount of work may be performed. Or owing to extreme excitement due to emotional states, or as the result of increased interest or of increased effort, a temporary spurt may affect the work curve. Two such spurts have been recognised in the laboratory investigations of the work curve, the one occurring at the start of work, the other as the work is known to be nearing its end. These "initial" and "end" spurts, as they have respectively been termed, may occur quite involuntarily. The initial spurt is the result of "freshness"; its analogue is seen in the behaviour of a horse just released from its stall, whilst the end spurt may be likened to the revived energies of the tired animal as it approaches its stable once more. The initial spurt is recognisable industrially after a few minutes' rest, though it may be obscured or even masked by the concurrent loss of incitement. The end spurt occurs often obviously as holiday time or as wage day approaches, or as the end of a given job looms fairly in view. "Intermediate" spurts are apt to occur after delays in waiting for the arrival of working material, especially when payment is being made by piece-rate.

Initial spurts are inevitable and end spurts do little harm; but frequent intermediate spurts, especially when they follow annoying and worrying delays, are to be deprecated. They are apt to be succeeded by periods of reduced activity, just as the excitement produced by alcohol gives place to a state of depression.

The differentiation of these factors of fatigue, practice, incitement, settlement and spurt, and the first attempts to measure them experimentally, were carried out some years ago by Kräpelin and his fellow workers in his psychological laboratory at Heidelberg.

The applied value of these purely scientific investigations is now sufficiently obvious. Let us examine an industrial daily work curve, a composite curve obtained from observation of the hourly output of a large number of operatives working an 8-hour day at a variety of engineering jobs, some of which involve dexterity, some hard muscular work, some rhythmical work, others tending machinery. The curve rises during the first three hours of the morning's work, reaching its maximum at the third hour. Despite any initial spurt (which under present industrial conditions may well be absent), the first hour's output is the lowest of the day. Incitement and settlement have to be attained before the maximal output can be expected. There may also be material or mechanical conditions which militate against a good output during the first hour of the day's work. In the case of the expert worker, there will be little improvement due to practice from one day to the next, still less from one hour of a day to the next. In the case of strenuous work at all events, fatigue may begin quite early in the day, but generally it will fail to be manifest at first, as it is counter-balanced by the simultaneous improvement of output due to settlement. But as fatigue increases, it more than balances such improvement, it may more than balance any increased output due to end spurt, so that the fourth hour of this composite work curve shows a fall, the output dropping to less than that recorded for the second hour. Part of the fall may be ascribed to preparation for leaving the factory for the dinner half-hour. After dinner, the output starts at a higher level, approximately equal to the second hour's output. A certain amount of fatigue has been lost by the half-hour's rest, but so has a certain amount of incitement; on the other hand, an initial spurt may add to the output during the first hour's work after dinner. The subsequent lack and after-effect of this spurt probably accounts for the drop in the second and third hours of the afternoon, and it may well be that increasing fatigue is responsible for some of the drop in the fourth or last hour of the day's work, in which the output falls nearly to that recorded during the first morning hour.

In such a curve there is no evidence of *undue* fatigue. Output rises uniformly during the first three hours of the morning; there is no undue fall during the last hour of the morning's or afternoon's work. The afternoon spell keeps at a high level, the average output being only slightly less than that of the morning's output. Compare such an 8-hour work curve with a 10-hour work curve, also from an engineering works. In the latter curve the morning's work starts from a much lower level, and the fall at the close of the morning's and afternoon's spells is far steeper. The afternoon's work shows a considerably lower average output than the morning's work. Here indeed we appear to see far clearer signs of fatigue; at all events the efficiency in the 8-hour day work curve is distinctly greater than that in the 10-hour day work curve.

Save in certain occupations involving exceptional strain, there is probably little excessive fatigue in the 8-hour day. But this does not mean that a four-hour spell of uninterrupted work necessarily gives the most effective results. A ten minutes' rest in each such spell has been found to increase the output by 26 per cent.; a five minutes' spell in every hour to increase the output by nearly 11 per cent. Perhaps the most striking effect of rest pauses is that recently recorded by Mr. John Loveday in his Report as Investigator to the Industrial Fatigue Research Board* upon the Boot and Shoe Industry, where over 44 per cent. increase in output was obtained by employing three, instead of two, girls at each press, each operative working 40 minutes and resting 20 minutes in every hour. There is good reason to believe that in many instances the introduction of regular rest pauses at intervals appropriate to the particular industry will lead to largely increased output.

In determining the presence of fatigue from an industrial work curve, various points of importance have to be borne in mind. In the first place, a certain amount of fatigue is not only inevitable, but also beneficial. All good work is fatiguing, but it must not be too fatiguing; it must be dissipatable with rest. If the output seriously diminishes during the last few hours of the day, if the output seriously diminishes day by day during the last few days of the week, if there is a large wastage of human material through illness, accidents, or

*"Preliminary Notes on the Boot and Shoe Industry." 1920. Report No. 10 of the Industrial Fatigue Research Board, 1s. 6d. H.M. Stationery Office.

labour turn over, if there is a large wastage of spoilt material, especially as the output becomes less, there are very strong reasons for concluding that undue fatigue is present.

In the second place, we have reason to suppose that quite apart from the effects of work, the human organism exhibits physiological fluctuations in efficiency which correspond in degree to the form of the normal daily work curve. Apart from any previous work, we improve in efficiency as the morning passes, we lose in efficiency as the mid-day meal approaches. "Similar variations in the capacity for the performance of a task," concludes Mr. B. Muscio who, as investigator to the Industrial Fatigue Research Board, recently carried out special laboratory experiments on this subject,* "may occur whether a person works or rests." "Characteristic variations in efficiency occur during a day in addition to variations produced by fatigue *due to work*." This conclusion is important for those who would liken the performance of human work to that of an engine which is most efficiently run at a uniform pace throughout the day. A uniform human output, hour by hour, is neither natural nor desirable. Apart from the physiological fluctuations occurring in the absence of work, there are the equally inevitable fluctuations in efficiency due to incitement, settlement, spurts and fatigue. To prescribe or to expect a uniform hourly output, as is actually done in certain factories and by certain persons, means the neglect of fundamental physiological and psychological principles. The natural work curve never takes the form of a straight line. Is it probable that man's efficiency is greatest when he is forced to work under unnatural conditions?

The conditions of industrial work are incomparable with those of long-distance running, in which maximal efficiency may be attained by uniform speed. A mechanical dead-level of factory output throughout the day is surely unrealisable in the light of the worker's increasing demands for greater responsibility, and for better opportunities of self-expression. Unconsciously man regulates his output according to his mental condition and according to his conditions of work. Discontentment inevitably spells diminished production. Reduction in hours of work almost invariably increases the hourly output. This does not necessarily mean previous ca'canny or restricted production. Man unconsciously distributes his day's expenditure of energy according to the length of his day's work. If the working hours be shortened, it takes many weeks, in some cases many months, as Dr. H. M. Vernon has shown in his Report as Investigator to the Industrial Fatigue Research Board,* before the full beneficial effect is attained. So long a period of adaptation affords fairly convincing proof of its unconscious character.

In the third place, we have to bear in mind the play of individual differences, and to recognise their vast importance. Some persons are more readily prone to spurts, some more easily lose the incitement or settlement they have acquired, than others. Some work "best in short explosive 'bursts,' others in longer, steadier spells."‡

Lastly, we must bear in mind that different kinds of work yield different forms of work curve. In a recent very suggestive Report to the United States Public Health Service (Public Health Bulletin No. 106) by Miss Goldmark and Miss Hopkins, on an Investigation by Mr. Sargant Florence and others into the comparison of an Eight-hour Plant and a Ten-hour Plant, the daily work curves are compared for dexterous hand work, for strenuous muscular hand work, for lathe machine work, and for miscellaneous machine work. The dexterous hand work appears to be most affected by settlement, the muscular hand work by fatigue, the lathe machine work by the rhythm of movement, the miscellaneous machine work by the constant speed of machinery. Consequently the work curve in the case of dexterous hand work shews a steady morning improvement with a fall after lunch, due to the loss of settlement; in the case of strenuous muscular hand work, the work curve shews an early and great fall of output in the morning spell, a great recovery after lunch, due to a loss of fatigue, and an enormous fall throughout the afternoon, especially towards the end of the day, when fatigue is at a maximum; in the case of the rhythmical lathe machine work,

*"Fluctuations in Mental Efficiency." British Journal of Psychology. 1920. Vol. X. Pt. 4, pp. 327-344.

*"The Speed of Adaptation of Output to Altered Hours of Work." 1920. Report No. 6 of the Industrial Fatigue Research Board. 1s. 0d. H.M. Stationery Office.

‡Cf. my "Mind and Work" (University of London Press. 1920, 6s. 0d.), where other considerations mentioned in this paper are more fully treated.

there is a slower development of efficiency, which, however, once acquired, is maintained throughout the day; and in the case of the miscellaneous machine work, there is a still more marked maintenance of the efficiency attained, doubtless owing to the speed of work being largely regulated by the constant running speed of the machine.

The importance of rhythmical movement in preserving uniformity of output is unquestionable. It tends to reduce the worker towards the level of an automaton. Provided that the work be not too strenuous, and provided that the automatic attitude can be maintained, efficiency remains unchanged for long periods. But the willingness to become an automaton, to spend one's life mechanically feeding a machine with a sheet of metal, adding up meaningless columns of figures, sweeping and cleaning the same rooms week after week, year after year, is becoming rarer, owing to the spread of education and as a result of the recent war, together with the spirit of discontentment and unrest to which they have given rise. In preserving the necessary favourable attitude for work, we may depend on unconscious factors—habits,—or on conscious factors—interests. The automaton is a creature of habits; the modern worker tends to demand interests. Whether work be carried out mechanically through mere habit, or purposefully through definite interests, the appropriate attitude has to be maintained. To maintain an attitude favourable to a given work, means to repress the development of other attitudes less favourable or unfavourable for that work. In other words all conflicting mental systems must be held in check. Untoward thoughts must be inhibited; and pyschical work is necessarily expended in such inhibition or repression. At first whether through habit or interest, this process of repression or inhibition is unconscious. Later it can only continue by voluntary effort. Finally, voluntary effort becomes fatigued, and boredom now already on the scene makes its presence more and more felt as interest has waned. Distracting thoughts are no longer under control. The mental system tends to disorder. Worry follows in the wake of contested boredom; and no cause of mental inefficiency is so potent as worry, whatever be its origin. It is inevitably accompanied by a wasteful dissipation of mental energy. The various conflicting mental systems, hitherto inhibited, now inhibit the regular orderly activity of mental work.

It is hardly surprising, then, that the frequency of accidents may follow the general course of the fatigue curve, and that with reduced hours accidents tend to become less numerous. But accident rate is also dependent on output; the smaller the output, the less the exposure to risk, *i.e.*, the fewer the accidents,—other things being equal. It would therefore seem desirable to determine the varying rates between accidents and output per hour *i.e.*, to determine the hourly accident risk per unit of output. In the recent American report already referred to, this has been done, and it is claimed that the close connexion between accident rate and fatigue is thereby established.

In the case of muscular fatigue, the results are partly due to an auto-inhibition. That is to say, the muscle itself sends nervous impulses up to the spinal cord, the final effect of which is to prevent impulses originating in the brain from throwing that muscle into further contraction. The impotence which finally ensues when a single finger joint has been successively flexed and extended, lifting a weight, as in the ergograph experiment, appears to be due to such auto-inhibition. But the muscle itself does not seem to be fatigued; at all events it is not exhausted. For if an electric current be applied immediately to the motor nerve supplying that muscle, the latter will at once contract. So it will voluntarily—indeed a fresh ergogram can be obtained—if the weight lifted be slightly reduced. But in ordinary life we do not use our muscles, as the single muscle is employed in the ergograph. We make successive use of a variety of muscles when a given movement has to be repeated. As one muscles tires, we help or replace its action by invoking the aid of another muscle. Hence, such auto-inhibition plays a secondary role. We have also to take into consideration the consumption of material manufactured by the muscle for use during each contraction, and the waste-products that arise from such consumption. A muscle may be regarded as storing up explosive material which is fired with each contraction. Probably this material in any muscle is never, save in quite exceptionally severe conditions of exhaustion,

entirely consumed. What is far more important is the removal of the waste products of muscular metabolism, first from the muscles themselves, secondly from the body as a whole to which they are borne in the blood and lymph stream. Their presence acts inimically on the activity not only of the muscular system but of the other bodily tissues, including the nervous system.

Needless muscular activity is therefore to be avoided in all kinds of industrial work. Seating accommodation, appropriate foot rests, and the abolition of stooping, increase the efficiency of the operatives' work. Numerous instances could be quoted where the output has also increased through improvements in ventilation, lighting, noise, vibration, temperature, etc. Adaptation helps mankind to neglect such unfavourable conditions; but man works generally better in the absence of the need for such adaptation.

Finally, industrial fatigue is reducible by systematic selection of those who are mentally and physically best fitted for the particular work required of them, and by careful investigations into the best arrangements of material and with the best "shorthand" methods of performing that work, followed by systematic instruction of those who are to be employed on it. The old methods of "trial and error" are now obsolescent, alike as regards the engagement of workers and as regards their picking up the methods of their work. Tests for vocational selection are being universally adopted. The scientific study of the workers' movements is being systematically undertaken. The relation of output to improved distribution of hours of work and rest is being widely investigated. For these and cognate purposes, we have in this country an Industrial Fatigue Research Board, actively carrying out inquiries on behalf of the Government for the industries as a whole, and the new National Institute of Industrial Psychology, established by voluntary support, making similar impartial scientific investigations for the benefit of individual industrial and commercial firms and their workers. The work of these two bodies cannot fail to promote industrial contentment and to ameliorate the various adverse conditions comprised in the term "Industrial Fatigue."

DISCUSSION.

Dr. T. M. Legge, C.B.E. (H.M. Medical Inspector of Factories), in opening the discussion, said that what was wrong with industrial fatigue more than anything else was that it had got a bad name. What the lecturer had been discussing that night had not been industrial fatigue so much as how to obtain industrial efficiency. A negative term like "Industrial Fatigue" was not half as good as a positive term like "Industrial Efficiency." If one desired to know what industrial fatigue really was, one had to go back to about 1815, when children of 9, 10 and 11 years of age had been brought by the cart-load into the mills of Lancashire and Yorkshire to work from 5 o'clock in the morning till 7 or 8 at night. It was interesting to read that even in those days there was a certain type of welfare supervisor, but in some mills they took the form of persons whose duty it was to strap children to their work when they fainted from the long hours and fatigue. With the present 8-hour day it was not physical fatigue that the worker was so likely to suffer from. In pre-war times, even with the 10-hour day, those who had been brought much into contact with factory operatives felt that by far the most important thing that could be done was a shortening of the working hours; but they had been led to that conclusion not so much by the evidence that had been brought before them of actual industrial fatigue, as by the fact that the worker had no leisure and no time to himself. The problem was not so much the question of fatigue as how to get rid of worry and boredom, and he really had got a solution which just showed the variety of ways in which the question of industrial fatigue could be studied. If boredom and worry were to be got rid of, a better atmosphere had to be produced. Why the present audience had enjoyed the lecture that night was because they were sitting in that hall which had a definite atmosphere, which made one have pleasure even in listening to a subject like industrial fatigue. The worker was unaware of the fact that he was working in an atmosphere which was infinitely finer than anybody had ever worked in before, and if he could only feel it, and see it, he would get rid of that sense of boredom, and feel that it was part of the great work of the world.

Mr. A. Robert Stelling said he desired to supplement the lecture by a few remarks and slides indicating what independent people had been doing in this country recently towards the elimination of industrial fatigue. While he did not wish to belittle the efforts of the Industrial Research Board, he thought a good deal of credit was due to Dr. Kent and his associates in Manchester, who were doing a good deal of very useful work.

(Mr. Stelling then proceeded to throw on the screen a series of slides showing details of various methods adopted in factories and workshops which tended towards the elimination of industrial fatigue.)

DR. R. FORTESCUE FOX said he desired to say a word on a practical aspect of the question as it affected the future of the workers whom they were endeavouring to reclaim from the disablement of war. One could not help feeling that if the things mentioned in the lecture were true as they were, of normal men, they were, *a fortiori*, more true of men who had been physically injured during the war. Many of those men were men of very great keenness and mental capacity but were physically handicapped. Physically handicapped men ought not to be necessarily debarred from the full exercise of their remaining faculty. He had felt, however, from the study of disabled men in actual work, that they were continually dependent upon the conditions in which they were placed. Nerve shocked and mentally shocked men had to be removed as far as possible from disturbing influences. At the present time there were between 40,000 and 50,000 workers of the *sub-normal* category in the country, and he looked with the greatest hopefulness to researches such as those the lecturer had brought before the meeting that night, for laying down the lines to be followed as a guide in finding for those men the conditions in which they could carry on and use their remaining faculty. He rather demurred from Dr. Legge, if he implied that this research was theoretical, because it was a most practical work, namely, making the best use of very fine material.

PROFESSOR EDGAR LEIGH COLLIS, M.D., said there was one point on which he would like to dwell, namely, the suggestion that the occurrence of industrial accidents was as it appeared hour by hour in a curve to be taken as representing the fatigue of those at work. He strongly felt himself—and there he joined issue with his friends in America—that industrial accidents were due to industrial risk. If a man was not exposed to risk in industry, he would not meet with an industrial accident. In other words, the faster one worked, the more chance there was of getting industrial accidents, and, therefore, there actually did occur a far greater likeness between the occurrence of accidents and the increase of output, than between the occurrence of accidents and the state of fatigue. If the working hours were cut down and fatigue lessened, the number of industrial accidents might be lessened though the people were working faster, but the shape of the curve of industrial accidents hour by hour would not alter. Therefore, he thought it was not quite fair to represent a curve of rising accidents during the morning or afternoon of a shift, and suggest that that really was a picture of the onset of fatigue during those hours. The general view which had been given of the way in which the human machine worked was one of the greatest interest, and what had struck him particularly was that health and efficiency and output had all to be obtained in exactly the same way. If one was going to get the greatest production of the best class with the fewest accidents, it was going to be obtained from the workers who were most healthy. The object of Labour and employers from that point of view was absolutely identical. Each party, in order to attain their end, must coincide on that point. If one looked upon the capitalist as a person who was merely looking out for his income (he did not believe such people existed), in order to attain his end, he must have the most healthy workmen to give the best output. On the other hand, if one looked upon the worker as a person whose only object in life was to get the highest possible wages (and he did not believe such persons existed), he must be a man of the best health in order to be able to do his work, as if he was not able to do his work he could not earn his wages. Therefore, if work-people were given contentment, health, and rightful rest, they would not only give the greatest output, but would be enabled to earn the highest possible wages. That would seem to be the tenour of thought which ran through the lecture.

COLONEL E. POTTINGER said one thought which had been running through his mind during the lecture and the discussion was how was the knowledge of the necessity of eliminating industrial fatigue and better methods of employment to be conveyed not only to the workers but to employers? Scientific management was not a thing which found favour with the working man, simply because he did not understand what it was. If the lecturer could suggest a means of propaganda to educate the working man into the methods mentioned that night, it would be a very valuable step forward. It could not be done by the Government, because any Government scheme was suspect of political motives. He noticed that the slides shown by the lecturer were American slides. He had found that the British workman did not like American methods thrust down his throat. Why did not British firms allow similar photographs to be taken in their own works? It was not only a question of educating the workmen, but of educating the employers.

DR. MYERS said it was one of the functions of the Institute of Industrial Psychology to undertake propaganda work of the kind mentioned.

The Chairman said, with reference to the question as to how it was possible to get the matter considered with more enthusiasm, both by employers and by the workers, he thought there were a variety of ways, and the Industrial Fatigue Research Board had done quite a considerable amount in that direction already. He believed the stage had now been passed when the workers as a class were opposed to the principles of scientific management. They realised that so far from being intended to overstrain them, the object of research into industrial fatigue was to reduce that strain upon them. It was no uncommon thing to-day for applications to be made to the Industrial Fatigue Research Society by the representatives of the Trades Unions themselves to have enquiries made. He could call to mind one instance where the workers applied for an enquiry of the sort, and the employers refused to participate in the enquiry. As to why they refused to participate, he thought it would be better to let Dr. Myers embark on a psychological analysis of the particular employers. There was a great deal that was being done in this country in the way of scientific management and labour-saving devices which was never talked about. Practically speaking, every factory in this country did it, and he thought the reason why similar photographs to those which came from America were not available in this country was, in the main, because Englishmen did not want to advertise what they were doing in that particular respect. They looked upon it as a natural part of their businesses, and possibly they did not want to give away too much to their rivals in the way of labour-saving devices. Coming to the question of industrial fatigue as a whole, he agreed with Dr. Legge, that there was no such thing as industrial fatigue. He did not wish to say that Dr. Myers' paper was about nothing, but he thought the title was a misnomer. He felt convinced that, speaking generally, there was no industry where men and women were overworked to-day to the detriment of their physical health. He did not believe that when the hours were longer, before the war, there was any industrial fatigue. The reason was, speaking generally again, that the human being exercised his natural instinct of self protection and did not work harder than his physical health and strength allowed him to do. Dr. Myers had made that point in the paper when he said "Man unconsciously distributes his day's expenditure of energy according to the length of the day's work." That meant that if a man had to work a long day he did not work so hard as if he had to work a short day. That had actually been the experience of shorter hours—that people had worked harder during that time and had put more into it. He did not mean to say that by having worked less hard when the hours were longer the workers had in any sense been shirking. Speaking broadly, he did not think the British worker was a shirker. He was one of the best workers in the world, and he had very little to learn from other nations in that respect. He did not wish to say that he always worked as hard as he could; he wanted his incentive, of course. There were many exceptions where individuals, and possibly classes, did not work as hard as they might, because the incentive was not there. He should find it difficult to defend the output of the normal bricklayer to-day. He could not help thinking that if the average number of bricks which were laid was taken, it would be found that it was smaller than one might reasonably expect, having the most sympathetic regard to the physical health and welfare of the bricklayer. The normal incentive was not at work there. The bricklayer was not afraid of losing his job, which was one of the greatest incentives there was to work and efficient production. The object of research into industrial fatigue was not with a view to spying out the weakness of the land, or in order to try to establish that men and women could work harder and longer hours than they did. The object was altogether different. It was in order to show them how to work more efficiently, how to save effort, and how to produce more with an equal amount of fatigue, or even with a less amount of fatigue, than before. That was the primary object. The secondary object was how to concentrate their work into as short a time as possible. If it was assumed that a man should dispose of a given amount of energy on his work during the day, it was surely admitted that he should put it into as short a time as possible, and get his output in a short time, rather than in a long time, not in order that he might use the balance of time for further work, but in order that he might have it for leisure. In other words, the research into industrial fatigue had for its object the concentration of work with a view to additional leisure. That was extremely important in these days, because, however successfully the experiment was carried out, the fact could never be got away from that certain classes of work were, and must be, dull. Dullness of work was not confined to those who worked with their hands. Many people did astonishingly dull work with their brains. He did not wish to over-rate the evil influence of the dullness of work. Very often monotonous work was not as bad as people said it was; but it was narrowing; that was the point. If one had one sole operation to do all day long it was narrowing to the mind, and the more automatic systematised and stereotyped work became, the more necessary it was that a man should have leisure

DR. MYERS said there were only two serious criticisms which had been raised on his paper. The first one had been raised by Prof. Collis in regard to some details of accidents, and it was impossible for him to enter into that at that late hour. The other complaint was as to the American origin of the slides. He certainly would not have shown those to a working-class audience. He had been glad to hear the Chairman state that the workers were now not so opposed to the term "scientific management." A year or so ago he (the speaker) had had very great difficulty in getting a working-class audience to listen to the remarks he had to make, although he had carefully avoided the term "scientific management," and also another term which stank in the nostrils of the working classes, namely, "industrial efficiency." Those were terms which had come to us from America, and in the early days of the American movement it had not been conducted in the way in which it was being now conducted there, or as it should be conducted in this country. There were grounds for differing from the way in which scientific management had been introduced into America. What suited one country did not suit another. The Labour Party had sent people over to America, and they had seen the great improvements that had been made in the methods out there, and were now far from being so opposed to it as they had been originally. As to the secrecy of British methods, he hoped that that was now disappearing.

MINERAL PRODUCTS OF CEYLON.

Ceylon's normal annual production of plumbago is about 30,000 tons, but in 1918 only about half that quantity was produced. The loss of the American market during the latter half of the year chiefly accounts for the difficulties experienced by plumbago dealers. The total quantity of plumbago exported in 1918 was 15,217 tons, valued at $1,570,462 as compared with 26,197 tons, valued at $7,071,803 in 1917. The United States took less than 55 per cent. of the quantity of Ceylon's plumbago in 1918, against over 80 per cent. in 1917. Prices of ordinary lumps during 1918 ranged from $81 to $210 per ton and chips from $56 to $115. This was a marked decrease from prices obtainable during the war.

The mica industry was revived during 1918. Demand from London caused the Government to appoint the Ceylon mineral surveyor as a shipping agent on a 5 per cent. commission basis. At the time the scheme came into working order hostilities ceased and the demand lessened, although it is believed the industry has good prospects. The mica shipped has been phlogopite; some muscovite is found, but only a small part of it is marketable.

A small monazite plant was erected during 1918, which by the end of the year was said to have separated about 20 tons of refined sand.

The market for gems was poor, as has been the case throughout the war.

THE PORCELAIN AND POTTERY INDUSTRY OF KINGTECHENG.

The Chinese Imperial Potteries at the time of the Empire were situated at Kingtecheng and were established about A.D. 1006. The pottery was manufactured for the royal family, but since the revolution the industry has deteriorated. The porcelain now produced is made for high officials at Peking and for general trade. From Kingtecheng the porcelain is sent down the River Chang to the Poyang Lake and across the lake to Kiukiang, whence it is distributed throughout China and to foreign markets under the name of Kiukiang porcelain, to distinguish it from the Imperial porcelain sent to Peking via the Grand Canal. Kingtecheng depends for its existence on its porcelain industry, in which are engaged 200 firms, 120 pottery kilns, 1,500 art shops, and over 2,000 form factories. The following particulars regarding the industry have been reported by the U.S. Consul-General at Hankow from data compiled by Mr. F. B. Lenz:—

"Kingtecheng is one of the four largest towns of China. Technically it is not a city. It is a town, because it has no wall. In reality it is a busy industrial city, with a population of 300,000. Two-thirds of the people are directly engaged in the manufacture and sale of porcelain and pottery. Historically it dates back to the Han dynasty, 200 A.D. It is during this period that the first records of the production of porcelain in China are found, though earthenware vessels were probably produced some centuries earlier.

"The city is located in the north-eastern part of Kiangsi Province, and can be most easily reached by launch and houseboat from Nanchang. Furnaces, warehouses, shops, and homes are all crowded togetner in a hopeless tangle. Great mounds of chipped and defective pottery are piled high along the river bank. These dumps are 30 or 40 feet thick, and represent the accumulated off-castings of the kilns for centuries.

"The location of Kingtecheng is not accidenta It became the pottery centre of the country and of the world centuries ago, because of the enormous quantities of excellent clay in the district around Poyang Lake. More than a dozen kinds of clay are found in the neighbourhood of the lake, except on the south side. At Chimen, which is just across the border in Anhwei Province, there is a whole mountain of fine white clay.

"Two very descriptive words are used by the Chinese in referring to the composition of porcelain—Ch'i Ku or porcelain bone, and Ch'ĭ Ro or porcelain flesh. The former gives strength and brittleness, while the latter adds toughness. Unless these clays are mixed in the right proportions the vessels will either sag or crack when placed in the furnace. Technically the "bone" clay is kaolin or China clay. It is an infusible substance derived from decomposed feldspar of granite. The 'flesh' clay is a white, fusible material from a mixture of feldspar and quartz. All these clays are hauled to Kingtechеng in the form of soft, white bricks by small flat-bottomed boats. Thousands of Chinese boatmen are engaged in this work.

"After the clays are thoroughly cleansed, sifted, and refined, they are kneaded together in varying proportions, usually by the feet, and are then ready for the potter. The wet lump of clay is placed on the stand of the potter's wheel, which is a Chinese invention. After revolving the wheel swiftly with a pole, the potter deftly forms a vase, bowl or plate with his hands. The piece is then removed and placed on a long tray in front of the worker, where it awaits the next artisan. Handles and decorations, made in moulds, are added, and then the whole is scraped smooth and allowed to dry until it becomes ready for the next process—the underglaze decoration. Several basic colours, like blue and red, can be painted on under the glaze. The glaze is next applied in various ways, by dipping, by blowing on with a tube, or by sprinkling. After the mark has been added the piece is ready for the furnace.

"Porcelain placed in the kiln to be fired has to be protected in strong, cylindrical, clay vessels called saggers. These trays can be used from three to six times before they are ready for the scrap heap. Every piece of porcelain, as it is set into the sagger, is placed on a small, round, clay chip, which has first been sprinkled with straw ashes. This prevents the fusing of the two pieces. In Kingtechеng the only fuel that is used is short pieces of pine wood. It was found that the fumes from coal discoloured the porcelain, and, accordingly, its use was discontinued. The wood is transported to Kingtechеng in river boats, often from sources two or three hundred miles distant.

"The kilns are large, egg-shaped ovens of yellow brick, 20 feet long by 12 feet high. Because of the intense heat most of them, as well as the chimneys, must be rebuilt annually. Every piece of porcelain is placed in the furnace with great precision and arranged according to the temperature which is necessary for its complete firing. Only certain pieces can be placed at the top of the kiln. The furnace, when full, is entirely bricked up, and the whole contents are kept at a temperature of 1,600 to 2,000 degrees Centigrade, usually for a night and a day, after which the kiln is allowed to cool off, and in due time the porcelain is removed. It has been found that one kiln keeps about 10 factories in operation. This completes the operation if no other decorations, other than the underglaze decorations, are desired; but if more elaborate colourings are used, further burnings in a kiln take place. In applying other ornamental designs the artist often spends weeks, even months, in completing a single piece.

"Porcelain is classified according to shape, as follows: (1) Yuan ch'i, or round ware, which includes cups, bowls, saucers, and plates; (2) Tso ch'i, or irregular rounds, including teapots, vases and small, round, flat paint and ink boxes; and (3) Tiao hsiang, or irregulars, such as images, statues, and representations of trees.

"A very interesting feature of the manufacturing process at Kingtechеng is that the factories produce porcelain according to shape, that is, Mr. Wang makes only round ware, while Mr. Li's factory is devoted entirely to the production of teapots. There is only one plant in Kingtechеng which produces all varieties of porcelain and pottery—the Kiangsi Porcelain Co. It was organised a number of years ago on a modern basis and is a paying concern. Its yearly output amounts to more than 100,000 dollars Mexican.

"Many women are engaged in various forms of porcelain production, such as painting, engraving, and lettering. The apprentice system prevails throughout the industry, as in every trade in China. It was very interesting to note the artistic ability of a number of small boys engaged in painting birds, flowers, fish, and bats—the latter being an omen of good fortune. No worker is paid for the number of hours he works: he is paid by the piece or by the job. On the other hand, no artisan must work too long. If a man is found overworking the limit, his fellow-workers will set upon him and severely beat him.

"According to the revenue collector's statement, between 5,000,000 and 6,000,000 dollars worth of porcelain is sold from Kingtechen every year. Most of this is for domestic use.

"Perhaps the most popular design of porcelain with foreigners is the 'ling lung' or rice pattern, found in dishes, cups, and bowls. The Chinese have learned the art of producing the foreign-style dinner sets in this pattern, and are finding a ready market for them. Skill and time are the essential elements in the production of this pattern. The wet clay is first formed into a crude cup or plate on the potter's wheel. After the piece has dried several hours, or a day, it is carefully scraped with a special kind of knife that conforms to the curvature of the vessel. The next step is to cut in the kernel-shaped holes. This is done with a small, flexible steel lance by a skilled workman.

After these small apertures have been completed the vessel is ready for the underglaze painting. Decorating finished, the next step is to apply the glazing fluid. This is a thin milky substance of high-grade porcelain in raw, cold form. Sometimes the bowl is dipped, but the liquid is usually put on with a soft wool brush. This operation is repeated 30 times, with an interval for drying, until all the holes are filled. Only about six coatings can be applied in a day. The piece is then fired in the usual manner. Coming out of the furnace, the filled holes stand out as beautiful, translucent designs."

* Mr. Lenz's article in full appeared in the *Millard's Review.*

TROPICAL "SWEET GRASS" IN TRINIDAD.

Considerable use is made of tropical "sweet grass" in Trinidad, especially during the Christmas season, for stuffing sachets, handkerchief cases, etc., and for making fans and other perfumed souvenirs of Trinidad, many of which are sent away. This "sweet grass," which has a strong and pleasant aromatic perfume that is retained almost indefinitely, includes the dried fibrous roots of the grass, the botanical name of which is *Vetiveria Zizanioides* Stapf., another name in common use being *Andropogon squarrosus.*

The following information concerning this grass was furnished to the U.S. Consul in Trinidad by the Director of Agriculture of the Trinidad Government:—

"It is a native of India, Ceylon, etc., and known as khus-khus or vetivier. It is grown locally on a moderate scale. In the Moruga and other districts it is planted to prevent soil slipping on road cuttings, etc. The fibrous roots collected and dried are well known here and in the East for their aromatic properties. I understand they are to some extent imported here from Martinique, bringing locally about 24 cents a pound, and then being retailed in small bundles at 1 cent each.

"There is thus no indication of an immediate export trade. One could doubtless be developed readily if the price offered for the dried roots was attractive to small growers. There is no particular trouble in preparing the dried roots, which can, I am informed, be gathered at any season of the year. Dry weather would, I presume, be preferable for preparing the product."

In Trinidad, adds the Consul, considerable use is made of this "sweet grass" to place among clothing, not merely because of the agreeable scent which it imparts, but also because it is believed to be as effective as camphor balls in keeping away moths and all kinds of insects. It is understood that in Cayenne, French Guiana, an effort is now being made to distil the perfume from the fibrous roots for commercial purposes.

GENERAL NOTE.

Motor Locomotives on Danish Railways.—A motor locomotive equipped with a Diesel crude oil motor similar to that used in motor ships, has been ordered by the Danish State Railways for the purpose of conducting tests to determine whether such locomotives could be used to advantage on the Danish railroads. On account of the difficulties in obtaining coal and its high price (four or five times as high as before the war), the State Railways, says an issue of *Politiken,* will give the new type of locomotive thorough tests in order to determine whether or not it would be cheaper to use low-grade oils for fuel. If the motor locomotive is found satisfactory it is possible that the State Railways will install a large number. Similar tests are now being made on Swedish railroads, and it is reported that motor locomotives are now in successful operation in England.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

February 2.—A. F. Baillie, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World." Professor Sir John Cadman, K.C.M.G., D.Sc., in the Chair.

February 8.—Edward C. de Segundo, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E., "Some Problems of Unemployment." George James Wardle, C.H., late Parliamentary Secretary, Ministry of Labour, in the Chair.

February 9.—William Rothenstein, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England." Sir Frank Warner, K.B.E., in the Chair.

February 16.—William Cramp, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice."

February 23, at 4.30 p.m.—Sir Daniel Hall, K.C.B., F.R.S., Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture, "The Present Position of Research in Agriculture." (Trueman Wood Lecture.) Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the Chair.

March 2.—CAPTAIN J. MANCLARK HOLLIS, Secretary to the Village Centres Council, "The Re-Education of the Disabled." Lord Henry Cavendish Bentinck, M.P., in the Chair.

INDIAN SECTION.

Fridays at 4.30 p.m.

FEBRUARY 18.—Paper to be announced later.

APRIL 22.—LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

MAY 27.—WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

COLONIAL SECTION.

TUESDAY, FEBRUARY 1, at 4.30 p.m.—G. C. CREELMAN, LL.D., B.S.A., Agent-General for Ontario, formerly Commissioner of Agriculture and President, Ontario Agricultural College, "Modern Agriculture." SIR DANIEL HALL, K.C.B., F.R.S., Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture, in the Chair.

INDIAN AND COLONIAL SECTIONS.
(Joint Meetings.)

At 4.30 p.m.

FRIDAY, MARCH 4.—WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

TUESDAY, MAY 3.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

DR. C. M. WILSON, "Industrial Medicine."

HOWARD LECTURES.

ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E., "Aero Engines." Three Lectures. January 17, 24, 31, at 8 p.m.

Syllabus.

LECTURE III.—Engines in use after the War—Comparative Tables of Piston Speeds, Mean Pressures, etc. — Conditions Governing and Limiting Further Progress—Variations of Thermodynamic Cycles—Regeneration—Possible Progress as regards Materials—Future Development of Aeroplane and Airship Engines.

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures, February 14, 21 and 28.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

MEETINGS FOR THE ENSUING WEEK *

TUESDAY FEBRUARY 1..Royal Institution, Albemarle Street, W., 3 p.m. Hon. J. W. Fortescue, "The British Soldier since the Restoration." (Lecture I. In Peace.)

Civil Engineers, Institution of, Great George Street S.W., 5.30 p.m. Brevet-Major G. le Q. Martel "Bridging in the Field."

WEDNESDAY, FEBRUARY 2..Geological Society, Burlington House, W., 5.30 p.m.

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m. 1. Annual General Meeting, President's Address. 2. F. W. Smith, "Extract of Red Squill (*Scilla maritima*) as a Rat Poison." 3. W. Lowson, "The Composition of Harrogate Mineral Waters."

Royal Archæological Institute, at the Society of Antiquaries Burlington House, W., 4.30 p.m. Prof. F. M. Simpson, "Santa Sophia and the Mosques at Constantinople and Brusa."

THURSDAY, FEBRUARY 3..Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. 1. Mr G. Dobson, "Meteorology and Aviation." 2. Wing-Condr. H. W. S Outram, "Ground Engineering."

Royal Institution, Albemarle Street, W., 3 p.m. Dr. W. A. Herdman, "Oceanography." (Lecture I. "Great Exploring Expeditions.")

China Society, at the School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Mr. E. H. C. Walsh, "Central Tibet and Lhasa."

FRIDAY FEBRUARY 4..Royal Institution, Albemarle Street, W., 9 p.m. Dr. A. D. Waller, "The Electrical Expression of Human Emotion."

Philological Society, University College, W.C., 8 p.m. Mr. E. G. White, "Voice Production."

SATURDAY, FEBRUARY 5..Royal Institution, Albemarle Street, W., 3 p.m. Dr. P. C. Buck, "The Madrigal." (Lecture II.—"Technique.")

* For Meetings of the Royal Society of Arts, see page 149.

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FRIDAY, FEBRUARY 4, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

TUESDAY, FEBRUARY 8th, at 8 p.m. (Extra Meeting.) EDWARD C. DE SEGUNDO, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E., "Some Problems of Unemployment." George James Wardle, C.H., late Parliamentary Secretary, Ministry of Labour, in the Chair.

WEDNESDAY, FEBRUARY 9th, at 8 p.m. (Ordinary Meeting.) WILLIAM ROTHENSTEIN, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England." Sir Frank Warner, K.B.E., Ex-President of the Textile Institute, in the Chair.

HOWARD LECTURE.

On Monday evening, January 31st, Mr. ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E., delivered the third and final lecture of his course on "Aero Engines."

On the motion of the Chairman, SIR DUGALD CLERK, K.B.E., F.R.S., a vote of thanks was accorded to Mr. Chorlton for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

EIGHTH ORDINARY MEETING.

WEDNESDAY, JANUARY 26th, 1921; MR. W. GREENWOOD, M.P., Vice-President, British Cotton Industry Research Association, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Andrews, Leonard Poel, London.
Nanton, Brigadier-General H. C., C.B., C.I.E., London.
Pinn, Herbert John Stewart, Bushey, Herts.
Procter, Sir Henry Edward Edleston, C.B.E., London.
Stapley, George, London.
Thomas, Roger, B.Sc., Baghdad, Mesopotamia.

The following candidates were balloted for and duly elected Fellows of the Society:—

Baeza, Edmund Isaac, Barbados, B.W. Indies.
Bernard, Pierre Arnold, New York City, U.S.A.
Bindley, Captain H. Duncombe, Assoc. M. Inst. C.E., Kuala Lumpur, Federated Malay States.
Blackwell, Miss Clarice Evelyn, Crewe, Cheshire.
Clark, James O. M., Paisley, Scotland.
Crossley, Arthur William, C.M.G., D.Sc., Ph.D., F.R.S., Didsbury, Manchester.
Curtis, Hon. George Seymour, C.S.I., Bombay, India.
Dutt, Nirmal Kant, B.A., Calcutta, India.
Ghosh, Nirmal Kumar, Benares, India.
Gray, Vernon Foxwell, Delhi, India.
Greenwood, John Neill, Stocksbridge, near Sheffield.
Hewett, Arthur Frederick, B.Sc., University of Glasgow.
Jacob, Harry Morgan, London.
Lee Mun Pan, Kuala Lumpur, Federated Malay States.
Lim Nee Soon, J.P., Singapore, Straits Settlements.
Martin, Oswald Stuart, Calcutta, India.
Mawe, Frederick Henry, Malvern Wells.
Mustafi, Chunilal, Midnapur, Bengal, India.
Parish, Walter Woodbine, London.
Platt, Wallace T., Singapore, Straits Settlements.
P'Chient, Peter, Negri Sembilan, Federated Malay States.
Ross, James Watt, E. Molesey, Surrey.
Stordy, Colonel Robert J., C.B.E., D.S.O., London.
Walker, James William Boyd, F.S.I., Pahang, Federated Malay States.
Willson, Walter Stuart James, Calcutta, India.

A paper on "The Origin and Development of the Research Associations established by the Department of Scientific and Industrial Research" was read by MR. A. ABBOTT, M.A., Assistant Secretary of the Department.

The paper and discussion will be published in the *Journal* of February 18th.

COLONIAL SECTION.

TUESDAY, FEBRUARY 1st, 1921: SIR DANIEL HALL, K.C.B., F.R.S., Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture, in the Chair. A paper on "Modern Agriculture, with Special reference to Progress in Canada" was read by Mr. G. C. CREELMAN, LL.D., B.S.A., Agent-General for Ontario, and formerly Commissioner of Agriculture and President, Ontario Agricultural College.

The paper and discussion will be published in a subsequent number of the *Journal*.

BOOKS OF TICKETS.

Fellows are reminded that they have the privilege of giving admission to two friends to each of the Society's Meetings, and a book of tickets for this purpose will be sent to any Fellow who will apply for it to the Secretary.

PROCEEDINGS OF THE SOCIETY.

SEVENTH ORDINARY MEETING.

WEDNESDAY, JANUARY 19TH, 1921.

THE RIGHT HON. LORD ASKWITH, K.C.B., K.C., D.C.L., in the Chair.

THE FUTURE OF INDUSTRIAL MANAGEMENT.

By F. M. LAWSON, Assoc. M. Inst. C.E., A.M.I.Mech.E., Author of "Industrial Control."

When attention is given to the critical periods through which this nation has passed during the last few centuries, there is one remark made more often than any other, and that is that the nation has muddled through somehow. This national characteristic for muddling is so well-known that when war broke out in 1914, it was quite common to hear the remark, "We shall muddle through somehow, we always do." As a matter of fact, though, this remark is untrue, for it isn't the muddlers that pull us through; it is those who do not muddle, and we are apt to forget that, while there have been numerous cases of muddling, there are far more cases in which the ship has been steered through critical times without muddling.

If we compare these cases with the muddle cases, we find that in every case muddling only occurred when the crisis was preceded by realisation and preparation. If the realisation was only partial, then the preparation was only partial. Years ago Lord Roberts, owing to the growing demand in Germany for war, realised the world crisis through which we must pass. He strained every effort to get others to realise and prepare, but national realisation and preparation were only partial. The efforts saved a far greater calamity than actually occurred, because the territorials stepped into the gap.

Axiomatically, muddling may be stated to vary inversely with realisation and preparation. This is equally true in the individual, the factory or the nation. The word "muddle" is derived from that dense matter called "mud." Muddling of any sort is entirely due to density preventing the individuals or the nation from seeing.

Lord Roberts probably thought that the nation was extremely dense in not being able to see what must eventually happen. With him, knowledge was certainty.

The worst feature of density in the individual is that he cannot see that it is possible for others to see events which must shortly come to pass. He turns away with the remark: "You may think so, but I don't," and then, to show how hopelessly illogical he is, he goes into his office and engages himself in a calculation as to when he can promise delivery of a certain article. He estimates from certain data, machining time, etc., etc., and then writes a letter promising certain delivery in three to four weeks. He foretells an event in his own works which will shortly come to pass, and he is certain of this from true records of past work. And it is just those true records of back history which we must first possess in order to foresee future events.

There is one other aspect which must be mentioned—realisation is connected with demand. Thus Lord Roberts *realised* that there was a *demand* for war in Germany, and the individual *realised* that he must give a date for delivery because the customer wrote *demanding* it. Demand, if insistent enough, is always met sooner or later by supply; if sooner, then a crisis does not come, if later, then a crisis brings the supply or extinction.

In arriving at definite conclusions about the future of industrial management, it is, therefore, essential to have true records of the past to work from, to realise that

there is a demand and that this demand must be met by the supply.

To-day there is a demand for industrial peace. The supply will certainly meet the demand before long, for there are many willing workers on the supply, although it must be admitted that a crisis may have to come first. This, then, is the aspect of the future of industrial management which must be considered.

Two questions now arise; firstly, what is industrial unrest? and secondly, have we a true record of industrial peace in the past, and if so, what record have we showing how that peace was disturbed?

The first question can be answered briefly. Industrial unrest is very much the same as any other sort of unrest; it is that which develops from irritation. It is like the dog with a flea on him. The dog knows that there is only one way of getting rest, and that is by removing the source of the irritation. The industrial world is not so old and wise as the dog; it is in the puppy stage. It realises the irritation, but doesn't know that the irritation is caused by a flea. When the dog was a puppy, he was licked and watched over by his mother, but the time came when he was taken away and had to face the world alone. That is the age in which we find the industrial world to-day. It is being plagued and worried with a flea, and cannot find out the way to remove it, because it hasn't yet realised that it is a flea.

Now for the second question. Have we a true record of industrial peace in the past, and if so, what record have we showing how that peace was disturbed?

Collectively, as a Nation, we must own that we never have had absolute industrial peace, but there are many records of individual works and factories where industrial peace reigned for a long time. If all works and factories had been run on similar lines, then there would have been industrial peace among our records of the past, so that the best we can do is to draw our conclusions from some in which industrial peace existed, and see if we can find in that factory the origin of the irritation which disturbed the peace.

The growth of some of these factories or works in which industrial peace reigned was somewhat as follows:—

One man, perhaps only twenty years old, realised that there was a demand for a certain article. He launched out on a venture to meet this demand. He employed a lad for the first year or two, worked hard, saved money, invested it in his business by buying more tools and machines, employed more hands, until in a few years' time he was employing, perhaps, twenty hands. He worked with them, knew all about them, booked the orders for work, sent the accounts in and paid the men. He was the true director of that business, although his actual work was, perhaps, similar to that of a jobbing foreman in larger works. The works increased until he found it necessary to divide them into sections, placing foremen in each section. The oldest hands, if they desired promotion, were made foremen, the next oldest were made charge hands or leading hands. Every year these men found that they were improving their position. Slowly, but surely their responsibility grew. The works grew until there were perhaps a hundred hands employed. The master was the true director of that business although his actual work was perhaps similar to that of a works manager. And so the factory went on growing.

There was not a man in those works who would say a word against the master. He behaved fairly with them, encouraged them, helped them, insisted on discipline and good work, arranged his work so that there was no loafing, gave praise where praise was due, and promotion in due season to those qualified both by ambition and service for promotion. The result was a happy, contented workshop with a good output.

During this period of growth the master went through many anxious and critical times, all of which developed his vision by forcing realisation and preparation upon him.

He realised, when a delivery promise was broken, that there was a difficulty in obtaining orders from that customer again, and that it was essential to give reliable promises. He accordingly learnt to visualise his work, made notes of promises, and when one part was behind time for an order, told the man working on that part to work overtime.

Another critical time came with finance. He realised that it was because he was overstocked on certain material and learnt to visualise his work so that the stocks

were in balance. This visualisation of work enabled him to keep the men more fully employed and to plan his work ahead of each man so that there was no wasted time. He learnt that he could, by keeping his stocks in good balance, work with a smaller amount of money invested in his stock and get a slightly increased output per hand, owing to time saved in moving material, etc.

Minor critical times were constantly occurring; insubordination was dealt with after the case had been heard, by dismissal. There was only room for one master in those works. When a foreman was ill, or away on business, the master took on his work; he realised that a large amount of his work was to help where help was wanted, and there was no man in those works whom he could not help. No job was below his dignity. His vision to an outsider, who went round those works, was almost uncanny; he was developing it all the time unconsciously. He became, not only respected in his own works, but in the country side. He experienced little difficulty in getting work, because his customers could rely on his quality and his promises, his deed and his word.

Industrial peace reigned.

Now we must watch the growth of the flea, the growth of irritation and industrial unrest.

The master, realising that he is a self-educated man, and has missed something valuable by his loss of education, decides to give his son the best education possible. He sends him to the University, where he works hard and does very well, for he possesses the hereditary energy of his father.

At the age of twenty-two he has finished this education and comes to the works. He is too old to be put on the jobs which the lads are put on. What is the use of education if you are going to brush up floors? The master accordingly decides to attach him to the departments in turn so that he shall pick up the work or else he sends him to other works for a few years for the same purpose.

Attaching for the purpose of feeding on the experience that has grown by years of hard work, jumping to another department for the same purpose; jumping, attaching, feeding, jumping, attaching, feeding, here is something new in these works where progress has always been by straight lines from apprentice to workman, from workman to charge hand, from charge hand to foreman, from foreman to works' manager. But there is peace in these works; the workmen are loyal to the master, and are only too pleased to help the son of the master, who has always done them well, and it is only right that the master's son should be educated to carry on the business.

Yes, but the fact remains that the method of progress is a mental equivalent of the flea's method of progress, and so is the occupation when attached.

What, now, does the son learn in these departments to which he is attached?

He learns about the individual machines, the processes, the methods of handling work, the names of the parts, the shop vocabulary, the recording system, and in this learning he finds that his education helps him. But what chance has he of developing vision, of being able to visualise the position of the work, and the hundred other things which the master visualises without effort, almost unconsciously? The old master possesses this vision, the old master anticipates the critical times by preparing, he directs the flow of material through the factory, he knows the time that each job should take, from years of experience. Critical times are very rare, because of his vision, his realisation and preparation. Critical times in the departments are very rare because the foremen have developed vision by being so long in contact with their work, and with the master. The son sees none of these critical times ahead; he, consequently, develops no vision, cannot see the bottlenecks forming in the flow of work, cannot give a reliable estimate for some new work, and only gets the confidence of the men because he is the son of his father.

Well, the son becomes his father's right hand man, his assistant. The master owns to himself that the son has a lot to learn yet, but that will come in time.

The master dies. The son takes on the title of Works' Director.

Things run all right for a few months, because the old hands carry on the business. They had been used to do so when the old master was away; in fact, the oldest foreman had run the business for short periods before, and if he had been made director instead of the son, then the business would have continued to flourish.

The son, having stepped into his father's place, has to give promises for delivery. Before very long, one of the oldest friends of the old master calls about a broken promise. The son chases round the works to each foreman, urging every part, putting men on overtime so that time may be made up, switching men off other jobs so as to get this work out, because the old master's old friend has told him that it is the first time for ten years that a promise has been broken by this firm. The son upsets a lot of other work in order to get this work done, and the result of the upset is that more critical times of the same type soon come. Things get so bad that orders are cancelled; the men begin to grumble to the foremen because they are continually being switched on to other work. They say things used to run better than this, what is the young master doing?

The foremen do their best. They tell the young master that if he will only let them know what order to take the work in, that they can get it through, but that it is impossible for them to get work through if they are put red hot on to one job one day, and told to drop this the next day because something else is more important. They let the young master know that the men are a bit upset and *irritated* because they are continually being *jumped* off one job on to another.

This worries the son. He turns it over in his mind, reads what other firms are doing, studies scientific management and decides that order of work or planning departments are necessary. He *jumps* in a new man from outside, who has had experience in starting and running these departments, and tells the foremen that the new man will issue them instructions about the order in which the work must be taken. The foremen naturally feel a bit *irritated* about having to take instructions from a new man; it wasn't necessary with the old master, why is it now? They are told that it is because the works are growing so fast, that other firms have found it necessary and are reaping benefit from it. The foremen still possess the old spirit of loyalty to the old master, and make the best of it. The young master hasn't sufficient vision to see that he is trading on this loyalty, and when, in a few months' time the new man reports an improvement, the young master *jumps* to the conclusion that he was right and the foreman was wrong. He hasn't sufficient vision to look back into the old records and see that the efficiency is still very low compared with what existed with the old master. The new man reports that by increasing his staff he can get still better results. The young master agrees, and *jumps* in more men from outside, but being without any vision of the problem, he is unable even to select the right men. He believes that men of his own training and education must be the right sort, and accordingly he engages men with good education rather than with experience. And when these men tell him that they have never had experience in the works, he replies: "You will soon pick that part up; if you like you can be attached to one of the departments for this purpose." Jumping, attaching and feeding are becoming natural with him. Yes, and during this time the poor puppy is being irritated more and more by the growth of the original flea's family.

It is hardly necessary to spend much time on the growth of other departments. The broken promises have killed a lot of the old trade; salesmen are required in order to smooth down the customers who are upset with bad deliveries; work has to be sought. The son *jumps* to the conclusion that it is competition which is making work difficult to get. The old master had learnt that there was no difficulty in getting orders if the customers could rely on the promises and the quality. Owing to the son's lack of vision, the quality is not so good as it was with the old master. An outside man has to be *jumped* in to deal with complaints about quality. After a few months he reports that a separate inspection department is necessary, because the foremen don't know their job or haven't sufficient time to look after quality. The son *jumps* to the conclusion that this is right, and starts a separate inspection department, with the result that the *irritation* is increased. Finance then becomes critical owing to all this unproductive labour. The son decides to engage a cost manager. He *jumps* in a highly paid man of his own mentality and the cost office grows. The costs, after the job is finished, are often far less accurate than the estimate which the old master could make in a few minutes, and the prices are *jumped* up to cover all the extra unproductive labour.

In the meantime, the old hands are tired out with the irritation. Some commit

mental suicide. They turn into parasites living on the flea's back. They don't care so long as they have a snug billet (the instinct of the flea asserting itself). Others, owing to the irritation, leave their old work-home rather than lose their self respect. A few face the irritation and put up with a lot of backbiting, because they are loyal to the old master.

During this period of growth, the energetic son is working hard, and must be developing some power. It is obviously not vision. It is not sympathy and feeling for others. It is not a keen business scent for bargains, else he would not overload his works with unproductive labour. What is it then? Well, he finds himself surrounded with "big" men, he has to co-ordinate the work of these men, because he finds a certain amount of friction existing between them. To co-ordinate their efforts he has formal meetings, with long agendas, long discussions and long decisions. He takes the chair. He develops a taste for being chairman—he may also develop a business ear for gossip so as to be wise before the meetings. His taste for occupying the chair develops into a taste for speaking in public, and from this he may arrive at the position of being a Member of Parliament, where he meets many of his own mentality, lacking in business scent, vision and feeling for others, and overdeveloped mentally in a taste for public speaking and possessing, perhaps, the same keen ear for gossip.

The author has evolved the type of man who becomes a Member of Parliament rather than the type who becomes a capitalist, because future legislation is the objective of this paper, and it is necessary to show the weaknesses of present legislators with regard to this future legislation.

If the son had possessed a business scent for a bargain when he took charge of the works, then the growth of unrest would have been the same, but it would not have arisen from overloading the factory with unproductive labour; it would have arisen owing to an abnormally keen business scent, from sweating labour and such like blood sucking methods which have soiled so many pages of our industrial history, and are still soiling them.

Before proceeding to develop future legislation to cure industrial unrest, it is, perhaps, as well to give some evidence of the truth of this statement of growth, for if this statement is not true, then the deductions regarding the future cannot be true.

In many works which twenty or thirty years ago had about ten per cent. unproductive workers out of the total hands employed, there are to-day between twenty and forty per cent. unproductive workers.

In some competitive businesses to-day the keen scented man is running his business with ten per cent. unproductive labour, while his competitor of the M.P. type has 30 per cent. unproductive labour.

In many works the author found last year that over 30 per cent. of the letters written and received were about broken promises.

In many works the staff have been told that they must not lose orders on the delivery dates. They have been instructed to promise a short delivery date, which, owing to the amount of work promised ahead, cannot possibly be kept. They have, diplomatically, been taught to tell lies so as to book the order. Yes, and the same firms start welfare departments. Lying and welfare hand-in-hand. What dissimulation! What hypocrisy!

Attention must now be given to the future, and since so few know how to forecast events, it is necessary to explain the principle briefly.

Consider a given straight line which has to be produced. In order to produce it so as to be straight and true, with the given part, it is necessary to have a straight edge, or, in other words, the extension to a given line is generated by a parallel line.

If you wish to produce legislation in the future which will bring industrial peace, it is easiest to generate it by means of parallel legislation, which has brought peace.

If, however, those who are responsible for bringing in legislation are lacking in vision, and if, moreover, such legislation is so revolutionary that many of them would lose their jobs, owing to their lack of vision, is it likely that such legislation would come from them? Isn't it more likely that pressure will have to be put on them by those who possess more vision by virtue of having progressed slowly and surely, like the hands in the old factory? The workers are not so lacking in vision as most Members of Parliament, but long words don't appeal to them and to talk to them about parallel future legislation makes

no impression. The workers, in order to get roused, must first have their imagination stimulated; they can then be shewn where they have gone wrong in their attempt to meet the demand for industrial peace, and, finally can be given a principle on which to go nap.

The workers, in their youth, were taught to connect parables with principles, and they still—unconsciously perhaps in many cases—connect them.

The parable or parallel, as the author prefers to call it, which will first tickle the imagination of the workers and then show them where they have gone wrong and lead them to a principle, is the parallel of the flea and the human errors of thought which are causing industrial unrest to-day.

In dealing with this particular parallel, the author has been interested to note that all accepted facts concerning the flea have a true mental parallel in causing unrest, and he would ask the patience of his present audience while he shows how the parallel can be used in a most homely way to provide forcible illustration for a working-class audience.

Firstly, can a flea see? Mr. Russell in his book, "The Flea," writes: "Presumably all fleas of long ago had eyes, and those that are now blind have lost their organs of sight from disuse. . . Entomologsts believe that the power of vision is probably confined to very near objects . . . . there is no reason to believe that fleas can distinguish colours or can discern any object more than a few inches away. It is enough for their purpose to perceive from which point light comes upon them and to make all dispatch to escape in the opposite direction." Isn't mankind of the type already sketched losing his vision from disuse? Does not this type, as soon as the old hands try to throw light on the difficulties jump in the opposite direction and forsake the advice of the experienced men, and follow the advice of the inexperienced men?

Again, the flea can jump to thirty times his own height, and the type of man who follows his example may be found in positions of responsibility thirty times beyond his mental reach. Didn't the son become works' director when his position should have been that of charge hand or foreman?

Again, the flea is hard to kill, and soft words will not kill the mental flea. He can only be killed by the hard words of righteous indignation, well rubbed in. Did the old hands kill the mental flea with their loyal soft words? and cannot you recollect an occasion in your own life when some good, hard, straight talking made you alter your opinion?

Immerse the flea in cold water and he will not be drowned; immerse him in hot water and he is killed. In a similar way cases are on record where the mental flea has been killed by getting into hot water. For example, in 1875, Mr. Plimsoll had been working very hard to bring in a Merchant Shipping Bill to legalise what is now known as the Plimsoll line in a ship. His Bill was defeated by three votes. Thereupon Mr. Plimsoll upset the tables of the money changers and the seat of them that sold doves in the House of Commons, lost control of his temper, slanged everybody, threatened to expose names, and finally rushed out of the house in a state of wild excitement. Although Mr. Disraeli moved: "That the Speaker do reprimand Mr. Plimsoll for his disorderly behaviour," he was not reprimanded. The publicity given to the scene stimulated the vision of his fellow country men, who realised that Mr. Plimsoll was right in principle, and those who voted against the Bill realised that they had got into hot water. The result was a sudden switch round on the part of the Government, and the pushing through by force of a Merchant Shipping Bill which met, for the moment, some of the difficulties of the case.

Some such homely parallels as these should go far to bring realisation of the mental irritation, which the author maintains is the true cause of industrial unrest. Such realisation will increase the demand for industrial peace. And realisation of the fact that it is a mental flea which is causing industrial unrest, must come before this demand for industrial peace can be met by the supply.

To attempt to kill the mental flea is dangerous work; it means hard words and lost tempers, which may lead to a bloody revolution. We must not have a bloody revolution, because that is only encouraging the mental flea; it is jumping to the conclusion that there is no other method.

How are we going to get rid of the mental flea then? Let the homely parallel be continued further.

A trained performing flea can draw weights eighty times heavier than himself

without any apparent effort, and the man who harnesses his mind to straight line thinking can move mountains of thought. Didn't Euclid move mountains of thought? And cannot communities and individuals harnessed with straight line promotion draw the whole nation immeasurably nearer to industrial peace? The master, in whose works industrial peace reigned, obtained peace by straight line promotion and unrest commenced as soon as there was favouritism in promotion. If legislation was brought in, which made it compulsory for works' managers and works' directors to have had so many years' experience as an apprentice, workman, charge hand, foreman, etc., the greatest source of industrial unrest would be abolished. And if the workers, instead of imitating the flea in having strikes, so as to jump up their own wages, would throw their whole strength into the principle of straight line promotion, then the good sense and conscience of all that is best in the nation would most certainly support them.

We can now turn to the simple method of producing legislation in the future, which will bring industrial peace. This, like the straight line, must be generated by means of parallel legislation which has brought peace.

The industrial world puppy has an elder brother called the Merchant Service Dog. This sea-dog behaved like a prize bull-dog during the war. Risks to life and limb didn't worry him; he didn't strike or grumble against his lot. He knew that the war had to be won and he did his bit. At times he looked round with a disgusted and puzzled countenance at his younger brother, the industrial world puppy, who was behaving like a mongrel and showing every sign of bad breeding. Disgusted, because he was shirking his duty. Puzzled, because he knew that the same blood existed in his own body as in that of the puppy.

Why was the young pup behaving like this instead of doing his bit?

Why, because the sea-dog harnessed his flea many years ago. He harnessed it with legislation, which empowered the Board of Trade to lay down rules for the conduct of examinations and qualifications of the applicant for masters' and mates' certificates. He only allowed those who had these qualifications to conduct the examinations. He didn't allow any son of a ship's captain to go as a passenger for a few voyages and then become captain. Then where is the sense in allowing any industrial captain's son to be a works' director or manager after being a passenger for a few months in the works, or any man to be a Member of Parliament after a few years' loafing; or a Peer's son to become a hereditary blocker of legislation?

Heredity and wealth are not, and never can be, true qualifications for positions of responsibility. Wealth is an excellent qualification for unemployment. The real, essential and true qualification for a position of responsibility is experience gained through length of service in all the different positions of responsibility, from the apprentice and upward, to that responsible position.

Once this principle is accepted and applied, then the administration of the incompetent diminishes and the administration of the competent increases.

Educate, by all means, but look upon education as the manure put into the ground; the care, attention and training given to the plant; the forcing, if necessary to make the crop mature earlier. Education never can take the place of experience, and if future legislators are to be thoroughly efficient, there will have to be a straight-line-progress-experience qualification.

Isn't it certain, therefore, that if this demand for industrial peace is general, urgent and genuine, some such legislation, parallel in many respects to the Merchant Shipping Acts, will be introduced before long in the industrial world?

Can anyone put forward any other definite solution, which they can guarantee will bring industrial peace?

What are the objections to a Bill being introduced shortly which will make it necessary for all works' managers and works' directors to possess the equivalent to the various masters' and mates' certicates? Are the Members of the House of Commons so short-sighted that they cannot see that there is a principle at stake, which has been overlooked in the past? Would the labour party oppose such legislation? If the labour party represent the men that do the work in the country, they could not. Would the liberals oppose it? Can you imagine a true liberal opposing such legislation? Would the coalition party oppose it? Wouldn't the family practitioner who is in charge of this party rather welcome

a little peace, instead of spending his time in racing round the country doctoring strikes and arresting paralysis? The country to-day is faced with a Goliath of unrest, and the stone which the long-sighted David must fling at this giant is a legislative stone, and must be directed straight at the forehead.

To say how, or when, this legislation will be introduced, is impossible, but a big crisis must soon come if it is not introduced shortly, and then legislation of this sort will follow, for the only alternative is extinction.

The effect of straight-line-promotion legislation would be for men of experience only to become Captains of industry, and for Members of Parliament to be selected from these captains of industry. The working man with energy and ambition would know that he could rise to the highest position of responsibility in the country. The mother would realise that her daughters must do the rough work, the early rising, cooking and floor washing, in order to fit them for the responsibility of motherhood, for the administration of home affairs, and rising to be of value to the Nation in Parliament.

In a few years' time this nation would lead industrially, and other nations would follow her example. And when all nations have realised, accepted and applied this principle; when all nations have the control of affairs in the hands of the men, who have the maximum amount of vision, instead of in the hands of those who have developed a taste for talking and an ear for gossip, and who are led by the men possessing a keen scent for filthy lucre; then, and then only, can there exist a state in the world in which wars shall be no more, either industrially or internationally.

That the Millennium can be reached by this means is certain; that it is possible for the Millennium to dawn without any bloodshed is also certain, but it never can, and never will dawn unless there is first a re-generation of thought, and the world is prepared to adopt straight line promotion and straight line legislation, in the many and varying phases of life, one of which only has been dealt with in this paper.

DISCUSSION.

THE CHAIRMAN (The Right Hon. Lord Askwith, K.C.B., K.C., D.C.L.), in opening the discussion, said he could have wished that Sir Robert Hadfield, who had been first notified as being the Chairman of the meeting that night, had been present, because he could have spoken as a great employer of labour, though he (the Chairman) doubted whether Sir Robert could have strictly fulfilled the qualifications which the author had set forth as the real essential and true qualification for a position of responsibility, namely, experience gained through length of service in all the different positions of responsibility from an apprentice upwards.

He (the Chairman) could only make remarks from the point of view of an observer from his late official position as Chief Industrial Commissioner, and he trusted that the author would not take it amiss if he made some criticisms upon the paper. The paper had been very carefully prepared and dealt with only one aspect of the question. In the principles which the author had alluded to, he had undoubtedly spoken with some effect of the importance of experience in those who led industry, of the importance of sympathy between employers and employed, of the importance of men having as far as possible a direct interest in the result of their work, and also of the importance of young men being able to look forward to promotion to those positions to which they were capable of rising. But at the same time, the author's panacea for those things was put within a narrow compass, and was rather hard upon some people who it was suggested would be obliged to go through that course of training. It also depended upon certain assumptions which did not always arise in the majority of works in this country. For instance, the author hinted that if departments of costing or of welfare were established in works, the people who were called in would have no vision and would be of the same mentality as the son of the old employer to whom reference was made. Was that so? Very often a great employer of labour, if he desired to set up such sections (and in a great works they were almost a necessity) would employ from outside the best men whom money could command. His judgment might be wrong, but it did not follow that those men were not men who had had very great experience and were quite capable of carrying out the work which was entrusted to them. The author then suggested that there should be no power for any to enter into those trades, or to have any command of business, unless they had been through certain steps of promotion, unless they had such experience as would enable them to be captains in the particular industry to which they were allotted, and that nobody else was to have a chance. Was not that in some sense the very attitude the Building Trades were taking up at the present moment with regard to the introduction of ex-Service men into their industry? Was not it rather different from the principles which one might see hinted at in such plays as "Milestones"—a very remarkable work, which indicated that the young man growing up might have visions.

and, even if he had not been trained through all the stages, might not have such crystallised ideas as his father's before him, and might be able to expand the business upon new lines? The author's remedy was for the State to step in and to pass a law which was to stop industrial unrest. There he (the Chairman) was afraid that he must most emphatically differ from the author. Legislation of that kind would be quite futile in stopping that unrest. The claims that the author put forward were very great, and he asked: Could anyone put forward any other definite solution which they could guarantee would bring industrial peace? He (the Chairman) would say no. He would be a bold man who did. Certainly he himself should not venture to pretend to such a suggestion. The author then added: "A big crisis must soon come if legislation is not introduced shortly, and then legislation of this sort will follow, for the only alternative is extinction." That was very unpleasant, and required the scrutinising of the author's proposal with some care. Then the author looked to the future and said "That the millenium can be reached by this means is certain." He (the Chairman) must say that he had seldom heard such a considerable claim advanced as the possible result of a single Act of Parliament. As he had said, he did not suggest that he or anybody else could make any one suggestion that could deal with the whole question of industrial unrest. There might be many things which might tend to lessen it. In a book which he had recently published, "Industrial Problems and Disputes," he had tried to give certain views upon the matter, and on some of the sections concerning it, and he had summed up some of the points at the end of that book. Perhaps one short quotation from it might illustrate the point he was trying to make:—"It would be useless to say that the waves of the sea are always to be still, or that the movements of ambition, greed and interests will not lead to clashing from which struggles of strength will arise. The small minority actively engaged in promoting complete changes of society, followed all the more easily by the masses as organisations are enlarged or more closely knit in discipline, would alone be sufficient to prevent such a millenium. The example of other nations, either in political, industrial, or revolutionary movements, is not to be left out of account, although often magnified into undue importance and although unity at home is surely of more value than a vague alliance with contemptuous and foreign dictators of illegal violence. The preachings of publicists and onesided propaganda by enthusiasts urging what they would destroy, but not thinking of what they would retain, the very workings of the minds of men, must prevent placid contentment. It is vain to think that peace can be got by Acts of Parliament."—there he was in direct contradiction with the author—"however orderly the arrangements they propose or the benevolence they breathe, or by pensions, insurance, maximum prices, town planning, public works, or multifarious devices resulting in heavy and ever-increasing taxation. I find no answer in the interference of the politician in the struggles arising in industry, and in my opinion such interference should be rigidly curtailed. If the orderly advance of peaceful development is to be obtained in place of the surging storms of hatred and strife, there must be more knowledge, so that men should not blindly follow guides who may be blind. There must be simple and plain modes of bringing forward grievances and avoiding disputes by all honourable means, and of composing difficulties when they arise, justly and equitably. There must be efforts to improve the comfort of the workshop and its surroundings, reduce the monotony of work, and by all possible means obviate the fear of unemployment. There ought to be a strong effort by each industry to deal with the question of unemployment within that industry, a difficult but vital task. There must be an attempt at better personal understanding"—there he was with the author—"and chances given to the young to make use of their education, and by means of their brains and energy to have opportunity of service to others and to themselves. There must be desire of common interest, and, if possible, a unifying common interest, partly by the touch of human and personal sympathy, partly by the joint interest of material gain, with the ideal of joint service. It is the spirit, not paper systems, which alone can prevent war and reduce the reasons for industrial strife." Those were views which he had summed up in those words, and again he repeated that it was the spirit, and not paper systems, which could reduce industrial strife.

Mr. A. Robert Stelling said he really thought that the author had strained a point. There was no doubt that some of the men who had had greatness thrust upon them in industry had gone far to cause, through their short-sighted vision, a great deal of unrest, but he would ask the author if he seriously thought that such a deplorable picture as he had drawn of our captains of industry to-day was universal? He (the speaker) could not conceive it. He thought the young men of to-day, as a whole, had far more vision than the author gave them credit for. He thought the author went too far back when he tried to draw his parallel, because, between the stage of the old man going out of business and the young man taking it up and the present day, there had been the stage of the advent of the limited liability company. There was not the slightest doubt that a great deal of the workmen's irritation had arisen through the change from the personally conducted business to that business of the Limited Liability Co., because instead of having an owner of a business with whom the

workmen could talk and argue intelligently, there was a soulless intangible Board of Directors to which the workmen had no access. He thought it was from that feeling of intangibility of management that the conception of works committees arose to bring about a more human touch in factories. With regard to the future of industrial control, he thought that those works committees, with their associated district councils and national industrial councils, were going to play a very great part, and he thought himself that the future of industrial peace lay in the intelligent development of those committees and councils. Referring to the author's condemnation of what he described as unproductive labour, he (the speaker) knew a factory where the men actually working at the machine and at the vice numbered 100, and the men working at drawing boards in the offices numbered 165. That could not be called unproductive labour in that factory. It was a very efficient factory indeed, and he would say that whatever the ratio of men actually working with their hands at machines or benches to the other men employed, in an *efficient* factory there was *no* unproductive labour. The British working man to-day was beginning to realise that, and was coming to the conclusion that the cost clerks and planning clerks, and others were not carried by him. He was slowly coming to the realisation that they were essential to his comfort and peace of mind in the factory. In the industrial councils, more cognisance must be taken of what he called brains—of management. The Whitley Industrial Councils had, on the one hand, employers, and, on the other hand, workmen, but management as such, which was the co-ordinating factor between labour and capital, wa not represented. There must be some recognition of management in industrial councils. That brought him to say that a technique of management must be developed in order to produce real managers who could take adequate positions on those councils for the purpose of co-ordinating capital and labour. Specialists in management must be developed, and therefore management must be studied. Management to-day was a science. It required as much study and careful thought as the science of medicine. It was called "scientific management" for the sake of a term, and under scientific management was recognised the three-position plan of promotion which the author would probably describe as straight-line promotion. Recognising that, there was actually under the modern ideas of management a definite path upward and forward for each individual workman. Recognising that management was a science which must be studied, and a technique developed, there was being instituted in all our colleges a department of Industrial Administration for the purpose of training men to become foremen, foremen to become managers, and managers to take their position as managing directors or as leaders on those councils. It was in the intelligent working of those councils that he personally saw the future of industrial peace.

Mr. Alexander Siemens said he could only repeat what he had said as President of the Institution of Electrical Engineers in 1904, and as President of the Civil Engineers in 1910, namely, that modern industry, as represented by limited companies, was working in a way which could be compared with the making of a cup of tea. If one wanted to have a proper cup of tea, good tea leaves were required, also boiling water, and a person who knew how to pour the right quantity of water on the right quantity of tea leaves, just as in modern industry capital was required to provide the works, machinery, and wages, workmen to convert the raw material into the finished product, and management to put the right men on to the right material. The author spoke as if no good manager could be produced except by serving all through the different stages of journeyman, workman, foreman and so on. But the qualities required of a manager differed absolutely from the qualities required of a workman; and as far as the poor capitalist was concerned he was usually blamed for everything; he really had not a word to say in modern industry; all he could do practically was to accept the report of the directors; that was about the extent of his influence on modern industry. A workman could not be workman and manager, and a manager could not be manager and workman. That had been illustrated just lately in the great strike in Italy. There the workmen took possession of the factories and wanted to run the industry themselves, but they found out in a very few days that they could not do it, and they had to ask the managers to come back and do the management work.

Mr. J. F. Butterworth said he could not agree with the conclusions at which the author had arrived. He did not think for one moment that legislation was the panacea for industrial unrest. Listening to the author's remarks about the flea and the dog, he had wondered whether Mr. Lawson had ever heard those words of wisdom which had fallen from the lips of that hero of American fiction, David Harum, "A few fleas is good for a dog, for it keeps him from brooding on being a dog," and he (the speaker) thought that a few fleas on the industrial body were not bad for it, for the simple reason that it was only through discontent and unrest that those great reforms, for which the workers had to-day to thank their leaders and others, had come about. If a proper record system was kept in any works, if a worker ceased to become a unit and became an individual (and he could only become that under the record system) the worker knew he would come before the right parties and that sooner or later he was

sure of promotion. The record system brought about promotion by merit. It had been found that when records like that had been kept of the performance of the various workers, many men who, six months previously had been working in the boilershop shovelling coal, had turned out after a few months tuition some of the cleverest mechanics in the shop. He believed that scientific management, properly carried out and properly applied, would create industrial peace and contentment for both employers and employed. In all those works where it has been thoroughly and properly installed such a thing as a strike was unknown.

Mr. E. C. de Segundo agreed with every word the Chairman had said. He believed the only hope of industrial peace lay in the more rigid observations of the moral law, and everything that that involved and implied, in the relations existing between employers and employed.

The Author, in reply, said there was one point which he had brought out on which nobody had touched; how did they account for the restful condition in the Merchant Service and the unrest in the industrial world? During the war the one could not be compared with the other. The Merchant Service did its best and did not grumble, while the industrial world was in the most appallingly horrible state that it could possibly be in—grumbling, jumping up their prices and going out on strike, when their brothers were being slain at the front. All he could say was God help this country if we continued in the same way. He could not see any signs of any improvement since the war. Mr. Stelling had mentioned that he, the author, had gone back too far. That rather reminded him of remarks that had been made when the Whitley Report first came out. It had struck him at the time that that Whitley Report was building a lot of super-structure on to an edifice which had rotten foundations, and that sooner or later the Whitley Councils and all the other odd Councils were going to make that edifice top heavy. From what he had seen of labour in the north of England particularly, he was certain this country was not very far off from a big "bust up" and he did not believe, unless something was really done, that we were going to pull through. Instead of that edifice on insecure foundations, he wanted to see a new building started with the foundations dug down to the rock.

The Chairman, in moving a vote of thanks to the author, said he desired to correct one little inaccuracy in the author's reply. It was with regard to the Merchant Service. There had been a great many claims made during the war by the Merchant Service. He himself had settled the first of them in August, 1914, but they were settled without such incidents as strikes.

The vote of thanks was carried and the meeting terminated.

In further reply to the discussion, Mr. Lawson writes:—

The picture of the father and the son, which has been painted in this paper, is one which has been criticised as extreme. The author accepts this criticism as literally fair, because, during the last twenty-four years (most of which time he has spent as works manager or consulting engineer to works managers) he has come across men of the separate types of the father and the son. To co-ordinate such extreme types into one continuous picture naturally presents to the enemy that obvious place for attack where extremes meet. But this leaving of a lad to grow up to about the age of twenty-two and then giving him a smattering of the work constitutes a policy, which unfortunately a very large number of engineers subscribe to, and the author has found that these cases are quite common in engineering works, some cases being naturally worse than others. Thus while an extreme picture of the author's experience has been drawn, he knows that it is none the less true, because throughout his experience he has met with many cases of irritation and unrest, all of which he has traced back to this root source of men being placed in positions of responsibility, without experience all along the straight line of development to that responsible position.

Merely to say that it is the spirit, which alone can prevent wars and reduce the reasons for industrial strife is to prescribe an emetic for that spirit; while to act, as so many masters are acting to-day, in appointing "big" men who have not travelled along the straight line of promotion, is to administer poison to that spirit. An emetic may be the right antidote for a poison, but why allow the poison to be administered?

No worker, charge hand or foreman that the author has ever come across (and he has the good fortune to possess the confidence of a very large number) would object to a works manager or works director being in charge of the works if that manager had served his time at *one of the trades employed* in those works and had put in a few years as workman, charge hand and foreman in that trade. The very fact that a manager has progressed slowly and surely to the responsible position of works manager helps to increase the growth of the spirit in all the hands in those works, to make them realise that with effort they can arrive at that position and by so doing helps them in making that effort.

Writing in 1919 on the subject of exposed records,* the author said "at present direction "and control by exposed record is more in its

*See "Industrial Control," p. 125 (Pitmans).

"infancy than geometry was in the time of "Thales and Pythagoras. . . . . Developments "in those days were slow. Developments in "these days will be rapid and this generation "will see exposed records developing at a "furious pace." Since writing this the "Daily Mail" has started its campaign of exposed records of net sales. It is equally essential for all workers to have an exposed record that their master has had experience in all the different positions of responsibility from the apprentice and upward to that responsible position which he holds as for the advertiser to know that the paper in which his advertisement appears is read by so many people.

To those who have criticised the last two paragraphs of the paper, the author replies that before the Millennium can be said to have started it will be necessary to have the right men in the right places and to be able to maintain a steady flow of the right men for the right places. No man can be in the right place unless he has travelled along the right or straight line of promotion to that place. Everyone to-day should be engaged in helping to "make straight the way."

OBITUARY.

Sir Merton Russell Cotes.—Sir Merton Russell Cotes, who was elected a Fellow of the Royal Society of Arts in 1919, died at his residence in Bournemouth on the 27th ult. He was born at Tettenhall, near Wolverhampton, in 1835, and after being educated in Glasgow, he was in business in Manchester and Dublin, where he was resident secretary of the Scottish Amicable Life Assurance Society. In 1876 he settled in Bournemouth. Here he took a very active part in the life of the town. In 1883 he joined the Board of Improvement Commissioners, and was instrumental in establishing two hospitals and the planting of the cliffs to prevent erosion, the starting of the direction railway line connecting Bournemouth with London *via* Christchurch, the construction of the Undercliff Drive, and other works. He was Mayor in 1894 and 1895.

Sir Merton was well-known as a collector of works of art, and his loan collection of some 250 pictures was exhibited in many Corporation Art Galleries throughout the country over a period of 35 years. In 1908 he and Lady Russell Cotes presented to the town of Bournemouth their residence, East Cliff Hall, and its art contents, and since then they continued to make large gifts to Bournemouth charities. In 1909 Mr. Russell Cotes received a knighthood.

Sir Merton was a great traveller and visited many parts of the world. He explored and wrote a paper on the volcano of Mauna Loa, and the great crater of Kilauea, Hawaii, and he also explored the Pink and White Terraces in New Zealand.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

Tuesday, February 8.—Edward C. de Segundo, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E., "Some Problems of Unemployment." George James Wardle, C.H., late Parliamentary Secretary, Ministry of Labour, in the Chair.

February 9.—William Rothenstein, Principal, Royal College of Art, "Possibilities for the Improvement of Industrial Art in England." Sir Frank Warner, K.B.E., in the Chair.

February 16.—William Cramp, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice." Sir Joseph E. Petavel, K.B.E., D.Sc., F.R.S., in the Chair.

February 23, at 4.30 p.m.—Sir Daniel Hall, K.C.B., F.R.S., Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture, "The Present Position of Research in Agriculture." (Trueman Wood Lecture.) Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the Chair.

March 2.—Captain J. Manclark Hollis, Secretary to the Village Centres Council, "The Re-Education of the Disabled." Lord Henry Cavendish Bentinck, M.P., in the Chair.

Indian Section.

Fridays at 4.30 p.m.

April 22.—Lieut.-Colonel Sir Edward W. M. Grigg, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

May 27.—William Raitt, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

Indian and Colonial Sections.
(Joint Meetings.)

At 4.30 p.m.

Friday, March 18.—William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

Tuesday, May 3.—Sir Charles H. Bedford, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

DR. C. M. WILSON, "Industrial Medicine."

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures.

Syllabus.

LECTURE I.—FEBRUARY 14.—Introduction—Classification of Catalytic Action—Theories of Catalysis—Technical Difficulties.

LECTURE II.—FEBRUARY 21.—*Processes of Oxidation.*—Sulphuric Acid—Nitric Acid—Chlorine—Catalysts in the Gas Industry—Sulphur Recovery—Surface Combustion—Incandescent Mantles—Organic Industries—Formaldehyde—Drying Oils—Linoleum—Oxidation of Hydrocarbons.

LECTURE III.—FEBRUARY 28.—*Processes of Hydrogenation.*—Preparation and Purification of Hydrogen—Methane—Hexahydrobenzol—Oil Hardening—Synthesis of Ammonia—the Cracking of Oils—Synthetic Rubber.

Hydrolytic Processes.—Saponification—Glucose—Alcohol—Acetic Acid—Acetone and Ether.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

MEETINGS FOR THE ENSUING WEEK*

MONDAY, FEBRUARY 7.. Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m.

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Dr. A. J. McC. Routh, "Motherhood."

Electrical Engineers, Institution of (Western Section), Technical College, Bristol, 7 p.m. Lt.-Col. H. E. O'Brien, "The Application of Electric Locomotives to Main-line Traction on Railways."

Royal Institution, Albemarle Street, W., 5 p.m. General Monthly Meeting.

Engineers, Society of, at the Geological Society Burlington House, W., 5.30 p.m. Presidential Address by Lord Headley.

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. Dr. O. Silberrad, "The Erosion of Bronze Propellers."

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m. Mr. A. H. Davis, "The Acquisition of Land for Public Purposes in Egypt."

Geographical Society, 135, New Bond Street, W., 8.30 p.m., Dr. J. M. Arthur, "Mount Kenya."

Cleveland Institution of Engineers, at the Literary and Philosophical Society, Corporation Road, Middlesbrough, 6.30 p.m.

TUESDAY, FEBRUARY 8.. Electrical Engineers, Institution of (North Midland Centre), Hotel Metropole Leeds, 7 p.m. Mr. G. A. Juhlin, "Temperature Limits of Large Alternators."

(North Western Centre), 17, Albert Square, Manchester, 7 p.m. Presidential Address by Mr. Ll. B. Atkinson.

(Scottish Centre), 207, Bath Street, Glasgow, 7.30 p.m. Mr. A. E. McColl, "Automatic Protective Devices for Alternating Current Systems."

Asiatic Society, 74, Grosvenor Street, W., 4 p.m. Miss R. Houston, "Turkestan under Bolshevik Rule."

Royal Institution, Albemarle Street, W., 3 p.m. Hon. J. W. Fortescue, "The British Soldier since the Restoration." (Lecture II. In War.)

Civil Engineers, Institution of, Great George Street S.W., 5.30 p.m.1. "Cannon Street Bridge Strengthening." Mr. G. Ellson. 2. "Reconstruction of a Viaduct," Mr. F. W. A. Handman.

Zoological Society, Regent's Park, N.W., 5.30 p.m. 1. The Secretary, Report on the Additions made to the Society's Menagerie during the months of November and December, 1920. 2. Dr. C. F. Sonntag, (*a*) The Comparative Anatomy of the Tongues of the Mammalia.—II. Fam. Simiidæ. (*b*) A Contribution to the Anatomy of the Three-toed Sloth (*Bradypus tridactylus*). 3. Professor J. P. Hill, Exhibition of, and remarks upon, a Fœtus of the Three-toed Sloth (*Bradypus tridactylus*). 4. Mr. R. I. Pocock, Notes on the External Anatomy of the Three-toed Sloth (*Brachypus tridactylus*). 5. Lt.-Col. S. Monckton Copeman, Note on the Capture of a rare Parasitic Fly, *Hammomyia* (*Hylephila*) *unilineata Zett.* 6. Mr. D. M. S. Watson, The Basis of Classification of the Theriodontia.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m., Mr. A. H. Ashbolt, "Australian Opening for British Settlers and Industries."

Metals, Institute of (Scottish Section), 39, Elmbank Crescent, Glasgow, 8 p.m., Dr. G. H. Bailey, "Aluminium Production and Uses."

WEDNESDAY, FEBRUARY 9.. Civil Engineers, Institution of, Gt. George Street, S.W., 6 p.m. (Students' Meeting.) Mr. J. H. Barker, "Machinery Applied to Mass Production."

School of Oriental Studies, Finsbury Circus, E.C., 5 p.m., Professor T. W. Arnold, "The Origin and Development of Persian Painting."

THURSDAY, FEBRUARY 10.. Pottery and Glass Trades Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m. Councillor J. T. Fereday, "How Glass is made—with a brief History of the Discovery and Development of the Glassmakers' Art."

Royal Society, Burlington House, W., 4.30 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Dr. W. A. Herdman, "Oceanography" (Lecture II. Problems of the Plankton).

Historical Society, 22, Russell Square, W.C., 5 p.m. Anniversary.

FRIDAY, FEBRUARY 11... London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. Mr. T. Wilson, "The History of the Houses of Parliament."

Royal Institution, Albemarle Street, W., 9 p.m. Dr. F. W. Aston, "Isotopes and Atomic Weights."

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m. Annual General Meeting.

SATURDAY, FEBRUARY 12.. Royal Institution, Albemarle Street, W., 3 p.m. Mr. A. Fowler, "Spectroscopy." Lecture I.

*For Meetings of the Royal Society of Arts see page 163.

Announcements intended for insertion in the above list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the meeting.

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FRIDAY, FEBRUARY 11, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 14th, at 8 p.m. (Cantor Lecture.) ERIC K. RIDEAL, M.B.E., M.A., D.Sc., F.I.C., "Applications of Catalysis to Industrial Chemistry." (Lecture I.)

WEDNESDAY, FEBRUARY 16th, at 8 p.m. (Ordinary Meeting.) WILLIAM CRAMP, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice." SIR JOSEPH E. PETAVEL, K.B.E., D.Sc., F.R.S., Director of the National Physical Laboratory, in the Chair.

NINTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 2nd, 1921; PROFESSOR SIR JOHN CADMAN, K.C.M.G., D.Sc., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Barnes, Herbert Rushton, St. Petrocks, Llandudno.
Lombard, Norman, San Francisco, U.S.A.
Milward, Charles Frederick, J.P., Alvechurch, Worcestershire.
Sinclair, John H., New Glasgow, Nova Scotia,
Wood, H. A., Santa Elena, Argentina.

The following Candidates were balloted for and duly elected Fellows of the Society:

Birkett, Thomas, Wigston Hall, near Leicester.
Davenport, Dr. Isaah, Paris, France.
Harding, William Gerald, Windsor.
Napier, Archibald Scott, M.Inst.C.E., London.
Rollins, Dr. Herbert, Boston, Mass., U.S.A.

CANTOR LECTURE.

The Cantor Lectures on "Aluminium and its Alloys," by DR. WALTER ROSENHAIN, F.R.S., have been reprinted from the *Journal*, and the pamphlet (price 1s. 6d.) can be obtained on application to the Secretary, Royal Society of Arts, John Steet, Adelphi, W.C. 2.

A full list of the lectures; which have been published separately. and are still on sale, can also be obtained on application.

EFFICIENCY EXHIBITION, OLYMPIA.

The authorities of the *Daily Mail* Efficiency Exhibition have invited Fellows of the Royal Society of Arts to visit the Exhibition on Wednesday, February 16th. The Chairman and members of the Council of the Society will attend at the Prince's Rooms, Olympia, at 3 p.m., on that day to meet the Fellows.

Fellows of the Society who desire to be present and who have not yet received invitations, are requested to communicate with the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, JANUARY 21st, 1921.

SIR CLAUDE H. A. HILL, K.C.S.I., C.I.E., in the chair.

The paper read was:—

INDIAN TIMBERS.

By R. S. TROUP, M.A., C.I.E., Indian Forest Service,

Professor of Forestry at the University of Oxford.

Last July, two events took place in London the importance of which, from the point of view of the Empire's timber supplies, can hardly be overestimated: I allude to the British Empire Forestry Conference and the Empire Timber Exhibition, both of which served to focus attention on our existing timber resources and the steps necessary to ensure adequate provision for the future.

Many persons in this country are under the impression that teak is the only timber of importance produced by India; others more enlightened might add rosewood, and possibly also ebony and satinwood, though Ceylon is a more important producer of the two last-named than India. Many visitors to the Indian section of the Exhibition, therefore, must have been somewhat surprised to see such a large number of different woods, of whose existence they had had no previous idea, made up into panelling, high-class furniture, parquet flooring, balustrades, and a large number of miscellaneous articles, including even golf-clubs and fishing-rods. It may come as a further surprise to many that India can claim nearly, if not quite, 2,500 indigenous species of trees, of which oaks alone number nearly 40 species. Only a small proportion, it is true, rank at present as important timber trees, and of these only a portion can be placed in the category of trees yielding timbers likely to gain a footing on the markets of Europe; it is with these in particular that this paper will deal.

Before we proceed to consider some of the more important Indian timbers and their sources of supply, it would be as well to determine what classes of timber are suitable and available for export to this country, and what classes are not. It may be mentioned at the outset that durability, and in particular the capacity for resisting white ants, is the deciding factor in the choice of the timbers most widely used for constructional purposes in India, and woods which are not resistant to white ants are relegated to a secondary position so far as extensive local consumption goes. Since the white ant is happily unknown in this country, a number of very high-class woods, many with properties superior in some respects to those of timbers ranked as first-class in India, become available for export and are likely to be much more asked for in this country than they are in India, where the demand for timbers conspicuous for their beauty of colour and grain is limited. By common consent the three most important timbers of India are teak, sal, and deodar, all of which are resistant to white ants. Teak finds a footing on the home market because of its unique properties, for as a ship-building timber it has no equal, and the keen demand for it has raised prices to such a level that it cannot be employed in India to the extent to which it would otherwise be used. Sal and deodar, abundant though they are, are in such request locally for railway sleepers and constructional work that they may be ruled out of account as important export timbers, and the same applies to certain other durable timbers of which the supply is not in excess of the local requirements, and which can never be expected to command such high prices when exported as teak does.

A second important factor in the question of placing Indian timbers on the home market is that of comparative cost of freight. Recently sea freights have probably been higher than at any other time during the past hundred years, and in the early part of last year over £11 per 50 cubic feet was paid for freight from India. Freights have fallen since, and there is every hope that they will ultimately reach a reasonable level, for on this will depend to a considerable degree the possibility of developing a large export trade in Indian timber.

Recent figures show that freight charges from India to the United Kingdom are more than double those from Canada, and nearly double those from British Columbia, somewhat more than those from South America, but considerably less than those from Western Australia. This indicates what has actually been found to be the case in practice, namely, that whereas India can compete successfully with other countries as regards shipments of high-class timbers, she cannot compete with Scandinavia, Canada, and other countries in so far as coniferous and other timbers of the cheaper grades are concerned. This eliminates all idea of a successful export trade in Himalayan conifers, and in a large class of timbers which are without sufficient merit to command attention in this country, while it narrows down the choice to timbers suitable for high-class decorative or constructional work, furniture, and various other purposes demanding woods with special properties. Of these, however, it is doubtful if any part of the world can show as varied a selection as India can.

There are two other factors which cannot be ignored in connection with the development of an export trade in Indian timber; one is the distance of the forests from the sea-coast, and the other is the local demand. Generally speaking, the forests of the Himalaya and sub-Himalayan tract, except

possibly in Bengal and Assam, are so far from the coast that the long railway journey would render the cost of transport prohibitive, except in the case of specially valuable consignments, such as walnut burrs. As regards the local demand, this increases as a rule with the industrial development of the country; in a province which is highly developed industrially, like the United Provinces, there is little or no timber to spare for export after local demands have been satisfied.

Taking the above factors into consideration, and omitting regions where for climatic or other reasons the forests produce little or no timber suitable for export, it may be said that those parts of the Indian Empire in which the development of an export trade in timber gives most promise are Burma, the Andaman Islands, the west coast of the Peninsula, and possibly to some extent Bengal and Assam. Burma promises the widest scope, but the forests of the Andamans also contain many high-class timbers, which will be available in considerable quantity at no distant date, since an extensive development scheme is now being pushed on. The total forest area of Burma is estimated at 130,000 square miles, of which, however, only 20,000 square miles have so far been constituted "reserved forests," to be maintained permanently and managed systematically. On the basis of actual enumerations, and assuming that there are 50,000 square miles of forest in Burma where supplies of timber are such as to allow intensive working for trade purposes, Mr. Rodger, of the Indian Forest Service, has estimated that the quantity of timber, other than teak, standing in these forests, and comprising trees 3 ft. in girth and over, amounts to upwards of 584 million tons, of which 110 million tons consists of *pyinkado*, and 23 million tons of *in* (*eng*). Even allowing for all possible local demands and for the fact that a considerable proportion of this timber will be unsuitable for export, these figures indicate the great possibilities of Burma as an exporter of timber other than teak.

As regards the timbers themselves, time will not permit of a long recital of the numerous species which could be mentioned; a list of many of the more important Indian timbers will be found in the catalogue of the recent timber exhibition, and apart from this there is a fairly extensive literature on the subject. I shall confine myself, therefore, to a few remarks on some of the timbers which attracted attention at the Exhibition and which hold out good prospects in so far as the development of an export trade is concerned. Teak, the premier ship-building timber of the world, and the bulwark of the Burma timber trade, is so well known that I shall pass it by in silence. Among the most abundant timbers of Burma is the *pyinkado* or iron-wood (*Xylia dolabriformis*), reddish brown, extremely hard, strong, heavy and durable, and extensively used for railway sleepers and constructional work of all kinds; obtainable in large sizes, it would be much appreciated in this country for constructional work, and wherever great strength and durability are required: it finishes well, and makes admirable flooring. The *pyinkado* belongs to that great order of tropical timbers, the *Leguminosae*, and to the same order belongs the rosewood (*Dalbergia latifolia*), a hard compact wood, of a purple colour with dark streaks; this wood is already well-known in Europe, and is extensively used for pianoforte cases and furniture. It is shipped from the west coast of India, and before the war, much of it found its way to Germany. Of other species of *Dalbergia* may be mentioned *D. Sissoo*, a brown, handsomely streaked furniture wood of Northern India: although this wood is fully utilised in the country, there may be a possibility of obtaining specially selected consignments from Calcutta. *Dalbergia cultrata* is a hard, compact, dark purple or nearly black wood, much resembling rosewood, though not obtainable in such large sizes; there are considerable supplies in Burma. Of somewhat similar type, and belonging to the same great order, is *Millettia pendula*, also common in Burma; this dark chocolate-coloured wood is particularly handsome when made up into fancy articles and walking sticks, and is an excellent wood for parallel rulers and other mathematical instruments. *Padauk* is another leguminous timber. The true *padauk* (a Burmese name) is *Pterocarpus macrocarpus*, the Burma *padauk*, a brick-red to light-brown hard and very strong wood, which has been used for more purposes than any other wood at the Madras Gun-carriage Factory; it is obtainable from Burma in somewhat limited quantity. For decorative work the Burma *padauk* is surpassed

by the Andaman *padauk*, ***Pterocarpus dalbergioides***, a hard, strong, rich red wood, often with dark streaks: this wood, which is exported from the Andamans, is already well known and appreciated for decorative work of all kinds, including panelling and parquet flooring, as well as for high-class furniture, including billiard tables. It has been used to some extent in America for the construction of Pullman cars. The last example of the order *Leguminosae* which we need consider is *Albizzia Lebbek*, known in Burma and the Andamans as *kôkko*, sometimes termed East Indian walnut, and believed to be identical with a timber known on the American market as laurel-wood. It is a hard, dark, brown wood, often beautifully streaked and mottled; at the recent exhibition it was admirably displayed in the form of a dining-room table, a suite of chairs in the Chippendale style, and other articles of furniture. It is better known in America than in this country, where it deserves more attention. Future supplies will be available mainly from the Andamans, whence logs of considerable size are obtainable. The woods of *Albizzia procera* and *A. odoratissima* are very similar to that of *A. Lebbek*, and are probably mixed with it occasionally: they are available from many parts of India, and are common in Burma.

The dipterocarps, so called from their winged fruits, are members of a very important order of the Eastern tropics, and comprise such excellent timber trees as the *sal* (*Shorea robusta*) and the Burmese equivalents of the *sal*, namely, *thitya* (*Shorea obtusa*) and *ingyin* (*Pentacme suavis*); these are three timbers of great strength and durability, but the local demand for them is so great that it is doubtful if an extensive export trade in them could be developed. There are, however, two timbers belonging to this order which promise to have a great future in the markets of this country. One is the *gurjan* (*Dipterocarpus turbinatus* and other closely allied species), and the other the *in* or *eng* (*D. tuberculatus*). The former in particular is available in very large sizes: the bulk of it comes from the Andamans, where large supplies are available, but there are considerable supplies in Burma, where it goes by the name of *kanyin*. It is a light, reddish-brown wood, with a smooth, hard, even surface, and resisting grain, well suited for constructional work of all kinds, for flooring, and for railway carriage building. For the last-named purpose it is already making quite a reputation, and one of the leading railway companies has recently placed a large order for it: that company has tested it and found it stronger than English oak. At the timber exhibition, a room panelled entirely with this wood, finished without stain or polish of any kind, was most effective. Its suitability for plain wooden furniture was also well demonstrated by two bedsteads and by a garden table and chairs of a style usually made in teak at a much higher cost. *In* timber (*Dipterocarpus tuberculatus*) is very similar to *gurjan*, and is put to the same uses.

India possesses some good mahogany substitutes in *Pentace burmanica*, a beautiful satiny, red wood, with ribbon-like markings, species of *Cedrela* (*e.g.*, *C. Toona* and *C. multijuga*), *Amoora*, and *Chickrassia tabularis*. All but the first-named belong to the same order (*Meliaceae*) as Spanish mahogany. *Pentace* (Burmese *thitka*) is obtainable from Burma, and the others from Burma, Bengal and Assam; *Cedrela* is also obtainable to some extent from the West Coast.

Among the various Indian species of *Terminalia*, two deserve special mention *T. tomentosa* and *T. bialata*. The former is a hard, greyish-brown wood, variable in shade, but often beautifully marked and streaked with darker brown, resembling European walnut, but with a finer figure and richer colour. Some exquisite furniture made of this wood was displayed at the exhibition, including a complete bedroom suite, a writing bureau, a vocalion, and a set of small drawing-room tables: a whole room was also panelled with it, and was most effective. This wood requires careful selection owing to its variability, and careful seasoning in consequence of its tendency to split in the process; the wood used in the exhibition was artificially seasoned, and gave no trouble. Plentiful supplies of this timber are to be had from Burma and the West Coast. *Terminalia bialata* is a timber from the Andamans, of a silvery grey colour, beautifully streaked with darker streaks. At the exhibition it was displayed under the name of silver greywood, in the form of panelling, parquet flooring, staircase and balustrade, furniture and miscellaneous articles: the wood was universally admired, and should have a

great future before it. Like *T. tomentosa* it requires careful selection and seasoning. Another *Terminalia* of the Andamans is *T. Manii*, with a wood of fine quality, darker in colour than that of *T. bialata*.

Another wood which commanded attention at the exhibition, was *Adina cordifolia*, a bright yellow wood with a smooth, close, and even grain, which can be cut in any direction without splitting, and is particularly suitable for carving; it is a valuable wood for the finer kinds of cabinet work, such as the making of chairs of the Empire style. Its admirable turning properties make it one of the best woods for bobbins, for which purpose it is employed in India. It is obtainable in large size and in fair quantity from Burma and the West coast.

The most recent discovery in the way of carving woods is *Bursera serrata*, an even-grained, pinkish wood, obtainable in fair quantity from Burma. A handsome carved mirror frame of this wood was shewn at the exhibition, and the carver stated that it was the best wood he had ever used. It is also very suitable for set-squares and other mathematical instruments.

Fishermen will be interested in the discovery of what may become a rival to greenheart. This is the product of a Burmese tree, *Heterophragma Adenophyllum*, the wood of which resembles greenheart in appearance and properties. The wood is very tough and elastic, and is preferred to all others by the Burmans for making bows. It is never safe to prophesy how a wood will stand the test of time for an exacting purpose like the manufacture of fishing-rods, but a rod shown at the exhibition had all the spring and elasticity of a greenheart rod, and the wood did not develop those fine cracks which condemn certain other strong elastic woods when put to such a delicate use. This wood is worth a thorough trial. A very fair substitute for boxwood is to be found in the wood of certain species of *Gardenia* which grow in the open forests of the Indian Peninsula. A consignment of this wood recently fetched a good price in London. At the exhibition it was used with good effect for inlay work and for various turned articles.

This brief account of a few Indian woods will have to suffice by way of example, although it does not include a number of other high-class woods available in commercial quantities, such as the various species of *Artocarpus*, *Lagerstroemia*, *Hopea*, *Calophyllum*, *Michelia*, and others, and the remarkable variegated ebony known as Andaman marblewood (*Diospyros Kurzii*). The Indian timbers displayed at the recent exhibition are now to be seen at Messrs. Howard Bros.' premises, 4, Stanhope Street, and some of the exhibits of furniture are on view at Messrs. Waring and Gillow's establishment.

We may now proceed to the important question of establishing and developing markets for Indian timber in this country and elsewhere, but it will be necessary first to examine conditions as they have existed hitherto, and as we find them now. The state forests of British India are under the management of the Forest Department, which has charge of a total area of 251,000 square miles; each province has control of its own forests, and makes its own contracts, subject to a limited amount of supervision by the Government of India in important cases. Of what may be termed minor provinces with important forest areas, the Andamans and Coorg are under the direct control of the Government of India. Certain areas, at present aggregating 110,000 square miles, are set aside as reserved or protected forests, to be maintained and managed permanently as forest, so that regular supplies of timber are assured for the future. In certain cases the extraction and marketing of the timber is done by Government agency, while in other cases, trees are sold standing and extracted by purchasers, or tracts of forest are leased for a series of years, the lessee undertaking the felling and extraction under a contract which imposes certain restrictions for the prevention of unauthorised felling.

Hitherto the teak trade of Burma has held such powerful sway that the comparatively limited export trade in other timbers has paled into insignificance beside it. Apart from a certain amount of extraction by Government agency, the working of teak in Burma is mainly in the hands of a few large firms, who hold purchase contracts. These firms have established themselves so firmly in the teak trade, and have done so well in it, that they have made little or no serious effort to develop an export trade in other timbers; this is not surprising, considering that teak is easily and cheaply extracted by floating, and is a timber with an assured market, whereas most of the other valuable

timbers do not float, nor have they yet made their name on the markets of Europe. Progress in the past has undoubtedly been hampered by lack of facilities for the extraction of timber, in the shape of suitable systems of roads and other export works; this is particularly the case in Burma, where communications are notoriously backward. With the view of remedying matters the Government of India has recently started a new service of Forest Engineers, who will be specially trained in methods of timber extraction, and this should in time lead to improvements in this direction.

Efforts have been made by Government from time to time to induce timber firms, by the offer of liberal terms, to develop an export trade in timber other than teak, but the results have not been encouraging. I may mention in particular an offer made several years ago by the Burma Government of large quantities of *in* timber at very favourable rates for a limited period of time. It is perhaps fortunate that this offer was not accepted, because in introducing a new timber no useful purpose is served by placing on the market larger quantities than it can absorb: the proper course would be to introduce it in moderate quantities, with an assurance of larger and, above all, regular supplies in future. Past experience having shown the necessity for coming into closer touch with timber interests in the United Kingdom, if any success is to be achieved in the development of an export trade in Indian timbers, the Government of India recently appointed a well-known London firm as its agents for the sale of timber in Europe. It is hoped that this appointment will lead to a wider use in this country of the many high-class woods which India produces.

A great deal remains to be done in the way of determining the best methods of seasoning the various timbers; several of those sent home for the exhibition were seasoned artificially in London with complete success, and there is little doubt that artificial seasoning will play a prominent part in the future utilisation of Indian timbers. The importance of careful seasoning is not always fully recognised, otherwise there would be fewer complaints regarding the behaviour of timber when utilised; in introducing new woods on the market this is a matter of special importance, since first impressions count for a good deal, and a bad reputation once acquired, however undeservedly, is difficult to eradicate.

But one of the most important of all considerations is the careful selection on the spot of consignments to be exported, if necessary, after conversion into planks or other assortments; this indicates the necessity for employing competent agents for this work, men who are in close touch with the requirements of the home market, and who also have a thorough training in the technical part of their work. For however well an undertaking may be financed and managed from home, ultimate success must depend very largely on the capacity of the local manager. I cannot help feeling that a good deal more might be done in the way of developing the technical side of timber work, particularly in its application to countries like India, where new timbers have to be sought for and brought on to the market. A prudent mining company does not work its mines without the aid of trained mining engineers, nor are chemical works established and carried on without trained chemists. Yet timber companies employ assistants without any previous training in the technical side of their work, including some knowledge of the growth of trees and the structure, properties and identification of timbers.

Until such trained men are employed, there is not likely to be any rapid advance in the somewhat difficult work of establishing markets for new timbers. At present the question of establishing a first-class forestry training centre for the Empire is under consideration. Such an institution should be in a position to turn out men with a preliminary technical training in timber work. If the demand for such men arises, then the supply should follow as a matter of course, and the training could be adapted to meet different requirements. I would commend this question to the notice of those in the timber trade with reference not only to India, but also to other parts of the Empire.

While we have here dealt mainly with the development of an export trade in Indian timbers we cannot ignore the great possibilities of creating new wood-using industries within the country. The antiseptic treatment of timbers on a large scale should bring into use for railway sleepers and constructional purposes a large quantity of timber which is not sufficiently durable if used untreated. But for the war, and the difficulty of obtaining

creosote, more progress would have been made in this direction. A good deal has been said, in recent times, regarding the industrial development of India, and in this development timber-using industries should play an important part. A large wood-working institute has recently been established by the United Provinces Government near Bareilly, and this institute is beginning to demonstrate the practicability of employing Indian woods for purposes for which foreign woods have hitherto been used. Attached to the institute is a bobbin factory, which is turning out excellent bobbins, picking arms, spools and other articles. When the local bobbin industry becomes more firmly established, it is probable that India will cease to import beech-wood for the purpose, as she does at present. Among other important wood-using industries now being started in India is that of the manufacture of plywood. An enterprising firm has established a ply-wood factory in Assam, primarily for the manufacture of tea-boxes. There is room for considerable development in this direction, since the forests of India produce abundant supplies of timber well suited for the purpose, and there is no reason why India should import tea-shooks in quantity from Japan and elsewhere, as she has done in the past: on the contrary, with the possession of so many suitable woods, among which may be included the maples of the Himalaya, India should in time become an exporter of plywood.

I shall conclude this paper with a brief account of the part which Indian timbers played during the war. The figures available refer only to the period from April, 1917, to October, 1918, that is a period of about 18 months, during which timber supplies were in the hands of the Indian Munitions Board. The overseas destinations were Mesoptamia, Egypt and Salonika, and to a more limited extent Aden, East Africa, the Persian Gulf and other places. The total quantity of timber shipped to these destinations amounted to 198,000 tons, while, in addition, 30,000 tons were consumed for war purposes in India, making a total of 228,000 tons, or an average of about 12,600 tons a month. These figures include bamboos, but they do not include railway sleepers for over 1,800 miles of track. Supplies were maintained by the establishment of large timber depôts at Bombay, Karachi, and Rangoon, which were kept stocked with various assortments likely to be in demand, so that indents could be met as soon after receipt as possible. Successful efforts were made to substitute Indian for foreign timber in order to reduce the demands on shipping, and to encourage the use of Indian timbers. It is interesting to note, however, that for the manufacture of rifle-stocks no other Indian timber has yet been found equal to walnut: during the last few years numbers of rifle-stocks have been made of Himalayan walnut, which is the same as the European species, *Juglans regia*. Efforts were made during the war to find timbers suitable for aircraft construction. Of the woods tested, Andaman *padauk* was found suitable for propellers, and also as a substitute for ash for longerons, provided it is used where it does not require to be steamed and bent: a species of *Albizzia* (possibly *A. odoratissima* or *A. procera*), and rosewood (a sample grown in Java, and probably *Dalbergia latifolia*) were also pronounced suitable for propellers.

In conclusion, I hope that in the brief space of time at my disposal, I have been able to indicate in some slight degree the future possibilities in the way of utilising Indian timbers provided their exploitation and marketing are carried out intelligently.

[An excellent series of lantern views was shown and described by Professor Troup.]

DISCUSSION.

Sir Bradford Leslie, K.C.I.E., said that before India imported iron it was entirely dependent on charcoal iron produced in that country direct from the ore, and many miles af the track of the East Indian Railway were ballasted with the slag from that industry, indicating that the works in Bengal at the time were very extensive. It appeared to him that it would be exceedingly valuable if the manufacture of charcoal iron could be re-established in India as a village industry, because that iron was far superior to any other description of iron, especially for wire drawing, tin-plate work, and railway axles, which required to be extremely tough. Much of the timber which was now used as fuel for locomotives would, in his opinion, produce sufficient charcoal to manufacture a very large quantity of that superior charcoal iron, and there were mountains of high grade ore in Bengal which were paiticularly suitable for the purpose.

Professor Troup thought that Sir Bradford Leslie was probably referring to the days before

the discovery and the development of coal in India. Since the advent of coal in India the charcoal industry, which was at one time of great importance, had considerably dwindled, and, as far as he knew, it no longer existed on the scale it reached in the days to which Sir Bradford referred.

SIR BRADFORD LESLIE said he was advocating the revival of what was formerly a very extensive industry which produced iron superior to any of the iron imported from Europe.

PROFESSOR TROUP said he thought the Forest Department would welcome the revival of such an industry, because there was always a certain amount of waste material in the forests which might be profitably disposed of in that way.

THE CHAIRMAN (Sir Claude H. A. Hill), after paying a warm tribute to the interesting character of the paper read by Professor Troup, said it was perhaps fortunate that, owing to the geographical situation of the coniferous timbers of India, there was little or no risk of their being exploited to excess in the way in which similar timber had been exploited in the United States and Canada, thus causing grave anxiety in regard to future supplies. It must be admitted that the Government of India, while they had taken the lead within the Empire in scientific forestry and its development, had not on the whole proved very successful in the commercial exploitation of Indian timber, and that was the direction in which he hoped the revised arrangements for forest administration might progress in the future. Very few people realised the enormous timber resources of India, the extensive areas over which they were spread, and their immense variety, upon which it was hoped, some day, the Empire would be able to draw. Mr. Howard, of the well-known timber firm, had recently compiled a very valuable catalogue of timbers, but it did not give either the distribution in such a way as to make it clear to the average reader or the quantitative resources of the different varieties, and Professor Troup had enlightened those interested in the subject in those respects. Another point to which he wished to refer was the failure hitherto of the Government of India to enter upon a go-ahead policy in connection with commercial firms for the exploitation of Indian timber, and it was greatly to be wished that, with the co-operation of business men, an improvement would take place. Hitherto the British Empire had failed lamentably to develop a forest policy. This fact was emphasised at the recent Forestry Conference, at which delegates from all over the Empire bore unanimous testimony to the need for educating the public in connection with the formulation of a forest policy of a co-ordinated kind. It was to be hoped that the Empire had awakened out of its lethargy in that respect, and the various developments which had recently taken place seemed to be promising. First of all there was the assembling of the Forestry Conference, which was the work of the newly-constituted British Forestry Commission; then came the exhibition of timbers, which aroused a quite unexpected and very gratifying degree of interest; and quite recently a most interesting paper on forestry development within Great Britain was read before this Society by Lord Lovat. A further stage was the exceedingly interesting description of the timber resources of the Indian Empire which had just been given by Professor Troup. The author had stated that timber companies employed assistants without any previous training on the technical side of their work. The Forestry Commission were arranging for education in various grades of forestry, and it was earnestly to be desired that advantage should be taken of the opportunities thus offered, and that, as in the case of all other businesses of a scientific kind, merchants interested in timber exploitation would take care to see that their employees were given the opportunity of securing a scientific training. The paper was designed to indicate the opportunity offered to British and to Indian enterprise for the development of the timber trade of India. The author had described the forest resources in order that those who wished to consider the question of further development might know the conditions and to what authorities they should apply. Although he knew that politics had to be avoided in connection with such meetings of the Society, he desired to make a few remarks regarding the political situation, since it might be held to affect the value of the opportunity which now presented itself. He had heard it said, for example, that India was in such a condition of unrest that no one in his senses would care to invest money for the further exploitation of anything connected with India; and, in view of the kind of information which was from time to time telegraphed to England or published in England, he was not surprised at that kind of remark. He had spent a good deal of his life in India and had only recently returned from that country, but he would have hesitated to comment very definitely on the value of the information which was from time to time telegraphed home, had not his own impression been confirmed by enquiries from those who had still more recently come home. It was abundantly clear that the unrest in India had been very greatly magnified, and its extent exaggerated. In point of fact, his latest information from a valuable source was that the situation in September, October, and November, was definitely better than it was last April. He thought those remarks were relevant, because it was desirable to correct what he could not help feeling was a mistaken impression in regard

to the political atmosphere, and because it appeared to be genuinely the case that people were hesitating to develop trade relations with India on the score of the political situation. He did not feel qualified to speak on the really justifiable cause of trade hindrance with India, namely, the fluctuations in exchange; but, so far as the political side was concerned, he was glad to take the opportunity of expressing his own conviction that the news which had been published was both misleading and mistaken. He desired to suggest to the hospitality of the Royal Society of Arts that the process of exciting interest in forestry matters, which had taken the course he had described, should be followed up, if it could conveniently be arranged, by getting a commercial man interested in the timber trade to read a paper, in continuation of the present paper, giving the commercial side of the case.

MR. H. J. ELWES, F.R.S., said that one of the things that struck a newcomer to India in travelling from Bombay to Calcutta, or from Bombay to Madras, or Madras to Calcutta, was the extraordinary absence of timber. A great deal of bamboo and of scrub jungle was to be seen, but real timber trees were to be met with in only a few places. He was perfectly ready to admit, however, that in particular areas there were enormous resources of fine timber, but he was afraid he should not live to see the day when the Indian ryot would live in a better house than the wattle-and-daub hut in which he was compelled to live at present, owing to the absence of, or the cost of, timber. When the ryot could afford to use timber for his house, he did not believe there would be enough accessible timber in India to supply its own needs. Where the dense population was found there was little but shaded fruit trees; where the timber was found there were few roads or people. That, however, was a matter which our descendants would have to consider. Some of the Indian woods were very beautiful indeed, and he had been struggling for fifteen years on exactly the same line as the author to convince architects, timber users and the cabinetmakers of England that it would be worth their while to use them in this country. But, unfortunately, they had not adopted such a course. As long as merchants could get a cargo of foreign timber at a cheap price, without regard to quality, they would not bother their heads about buying 10-ton lots from India, however beautiful the timber might be. He believed the author would find that the vested interests which had existed for generations of firms engaged in the American, Canadian and Baltic timber trade would prove most difficult to overcome so far as Indian timber was concerned. It was, however, largely a question of price. The author knew much better than he did that the one thing which governed the value of timber was what it cost to get it out of the forest where it grew to the place where it was going to be used, and that was a point upon which it was extremely difficult to obtain information in any country other than America. In order to be able to compete with other countries, the Indian Government must study the most economical and up-to-date mechanical methods of handling timber in the woods, and he was very glad to find, when he was in America the previous year, that the Indian Government had sent an officer to America for the purpose of examining that problem. That gentleman had recently produced a report which had been published at the expense of the Government of India, and he desired to express his thanks to the Director General of Forests for having sent him one of the most interesting, valuable and beautifully illustrated reports that he had ever seen produced by any Government official, either in Europe or in India. It would repay the cost of the investigation and the printing of the report a thousand times over to the Indian Government if the methods and devices illustrated in the book were made use of as far as possible. The author of the report, however, very rightly said that it was largely a question of cost. If first class forest workers could be obtained for four annas a day, such as he used to get in Sikkim fifty years ago, it was open to discussion whether primitive methods would not in the end be cheaper in actual operation than very costly machinery which had to be superintended by an expert. To put valuable machinery into the hands of ordinary natives, or even ordinary Englishmen who had no practical knowledge of the use of such machinery, would lead to enormous waste and to many serious accidents, which would probably cause a great deal more trouble than the machinery was worth. Such questions would have to be very seriously considered by the Indian Forestry Department. After paying a visit to Japan and seeing the methods that were adopted there, he thought it might be wise for the Indian Forestry Department to send an officer to Japan to study the work being done there. He hoped the Chairman's suggestion, that the present paper should be followed by one written from the commercial side, would be adopted. Mr. Alexander Howard was the solitary timber merchant in England who had ever given him much information about timber, some of which it was very hard to obtain, and when Mr. Howard came back from India, he thought he would be able to follow up the present paper with one which might throw a good deal of cold water upon many of their wishes and hopes, but which would, at any rate, give a better idea of what was practicable from the timber merchant's point of view than the information they possessed at present.

Sir Charles Armstrong said the paper was so interesting and useful and so full of practical advice that he hoped it would be distributed amongst those who were taking a keen interest in the development of Indian timbers, and also amongst those who ought to do so. He had often wondered why it was that Indian timber had not been used in greater quantities in this country, particularly for furniture making. He agreed with the previous speaker, that the makers of this country did not care to handle a small amount of any particular wood; they liked to buy an article in quantity which they could obtain with great ease. Twenty years ago, when he was furnishing his bungalow in Bombay, he had the whole of the furniture made of Burma teak, by a first-class maker. When he left India, in 1914, he brought the furniture home with him, and he looked upon it as a first-class advertisement for a very excellent wood. It was admired by everybody, including furniture makers in this country. One of the difficulties connected with the use of certain Indian timbers was that they had to be transported a great distance before they reached a port. The heavy cost of handling and transporting the timbers to the port of embarkation seemed to place all the Northern Indian timbers out of the market altogether. In addition there was a sea freight of at least 6,000 miles, which added very considerably to the total cost, particularly as the distance was very much greater than that which timber from Canada, Scandinavia and other countries on the Continent had to travel. Probably that was one of the great reasons why trade had not freely developed between India and this country. The G.I.P. Railway, of which he was Chairman, started in Bombay and ran in a north-easterly direction to Nagpur, Jubbulpur and Delhi, passing through an area in which there was no timber of any great value. Therefore, any Indian timber that was used on the railway cost a great deal before it reached the line. As far as he remembered, the Indian woods used on the G.I.P. were the deodar, the sal and the pyinkado. The first two were very good indeed for rough work, for the flooring of wagons and also for sleepers, but sleepers were to some extent attacked by white ants. They were not very good for carriage work, as they were apt to warp and twist. Another wood, Cancra teak, had been found most excellent for carriage work of all kinds. It was a very ornamental wood, which the railway company was always glad to use. At the same time, Burma teak was the most popular timber. It was very easily worked, but unfortunately it cost a considerable sum of money. He doubted very much whether there would be a great market for Indian timbers in this country, although he thought there ought to be a great market for them in India itself. A great deal was heard at present about industrial development in India, and that was undoubtedly one of the industries which might be developed on a very large scale. The Chairman said that the Government of India were taking a much greater interest in forest work than they had done in the past, and he thought development on those lines was likely to produce very good results. He was very glad indeed to hear the Chairman's opinion that many of the telegrams and letters received from India in connection with what was called the unrest in that country were very much exaggerated. He agreed. Personally he thought a great deal of the present industrial unrest in India, as distinct from the political unrest which concerned a certain class of extremist politicians, had been brought about to a very large extent by the results of the war, particularly the high cost of living. The cost of living had more than doubled on the railway with which he was connected. Statements were placed before him when he was in India a few months ago, showing that the cost of the ordinary necessaries of life had risen by anything from 200 to 300 per cent., and it was very difficult for him to say that the figures were wrong. It had been quite impossible to raise wages to the same extent, and a great deal of the industrial unrest had been due to that cause. He did not see much hope of alleviation in that respect at the moment. Unfortunately the last monsoon was unsatisfactory, and, so far as was known at present, there had been no winter rains in India. It therefore looked as if food prices would remain at a high level for some time to come. He thought, however, that if the next monsoon was satisfactory conditions would improve, and that consequently there would be much less unrest among the population generally.

Mr. H. J. Elwes said he was informed on the previous day by the Agent-General for British Columbia that quite recently a very large quantity of British Columbia creosote wood had been shipped to Calcutta. If that was a fact it seemed to show that the cost of transport from the Himalayas was even greater than the figure mentioned in the paper. Having regard to the fact that about ten times more was paid for a day's labour in British Columbia than in India, one would have thought that the competition of British Columbia with Indian grown woods was impossible.

Mr. A. N. Howard thought it was a great pity that Mr. A. L. Howard could not be present to speak, because, with his wide knowledge of the subject, he would have been able to describe some of the very considerable successes that were being met with in the distribution of Indian timber. In that connection, besides the invaluable help of such high experts as the author, who always helped in every way he could, there was one thing that was of even

more assistance, and that was the knowledge that Indian timbers were essentially good—that their characters and decorative qualities were almost unequalled, and that in comparison with all the well known decorative timbers they were, as the Americans would say, a sound proposition. He thought he could observe without fear of contradiction that everybody in his firm was thoroughly convinced that the Indian timbers were sound, and that it was only British conservatism and natural dislike for anything new that had kept the Indian timbers out of their own. The war did more than anything else to lessen that conservatism, and the users of timber in this country began to realise that English and Colonial timbers should be fostered, and that it was no good relying on enemy countries for supplies of timber in war time. It was found that there was no equal in the world to English ash for aeroplane manufacture, and that there was quite a lot of good qualities in English oak which had been rather overlooked previously. He was sorry to say that this country was already lapsing into its former prejudices, and that the outlook at the moment for English timber was far from promising, especially with the present increased railway freights. It was to be hoped, however, that the British Empire Forestry Conference and the Empire Timber Exhibition would do much to counteract that tendency as far as Colonial timbers were concerned. It was said that it took a real salesman to sell anything that people did not want, but he thought there should be a rider added, that it made a lot of difference to the struggling salesman if he was thoroughly convinced in his own mind that he had got a good proposition to offer. That was so in the present case. It was known that there was no equal to padauk, laurel wood and Indian silver greywood for interior decorations, and that pyinkado and Indian Gurjun wood were the woods to be used where strength and durability were desired. It was probable that the last named was going to replace teak for a number of purposes. The results of the Empire Timber Exhibition had far exceeded the most optimistic expectations, and his firm had in consequence been literally besieged with enquiries and orders. Upwards of 200 enquiries at the Exhibition itself were dealt with, and innumerable samples of the various woods were despatched. Many buildings which were being put up at the present time in London and in the provinces would include panelling, doors, floorings and fittings done throughout in Indian silver greywood, padauk, laurel wood and Gurjun wood, and, as already mentioned by the author, the railways had taken up the wood in earnest. The author mentioned the importance of determining the best methods of seasoning the various timbers, and also getting out and shipping them in the correct specification and condition. Those were points of the utmost importance. Many cargoes of valuable timbers had been entirely ruined through ignorance of how to convert and through being shipped in a too fresh condition or cut at the wrong time of the year. It was also very important to know how actually to work the various materials in the shops. Every timber should be dealt with according to its own peculiarities, and, while it was found that the best finish could be obtained in one case from a plane, in other cases it could only be done with a scraper. He had been assured by one of the greatest experts in the actual working of decorative woods, that Indian woods, if handled properly, were not more expensive to finish than mahogany, oak, etc., and that an even better finish could be obtained.

Mr. J. S. Corbett reminded the meeting of a resolution passed at the Empire Forestry Conference to the effect that it would be in the interests of all concerned if an Empire Forestry Association were established. With the assistance of the Chairman, those who were interested in the movement would soon be in a position to make public the aims and objects of such an Association. The author had referred in the paper to the need of better education and more technical expert foresters being available. In addition to educating forest officers it was absolutely necessary to educate the general public as to the resources of the Empire, particularly with regard to the industry of forestry. The lack of knowledge that existed was, if anything, even more apparent with regard to the timbers of the British Islands. The establishment of an Empire Forestry Association would be of the greatest benefit not only to those who grew timber and were connected with its exploitation, but also to those who traded in timber of every variety. It was hoped that the scheme would appeal to all interested in forestry, from the grower to the merchant and the consumer. When the scheme was put before the public generally he hoped it would appreciate the importance of the subject and would see that the organisation was the success it ought to be.

Sir Murray Hammick, K.C.S.I., C.I.E., in proposing a vote of thanks to the author for his interesting and instructive paper, said he had spent the greater part of his life in the south of India, and had taken much interest in forestry during his service there. He desired to emphasise the point that not only should the Forestry Department in India exploit the public in this country, but that it could do a great deal more than it had hitherto done in puttng forward better material than it was at present possible to find in the markets of India. He had had a good deal of furniture made in India from Madras timbers, and he had suffered a good deal through unseasoned and unsuitable

timbers having been used. He had never been able to get a good timber without taking a considerable trouble to find it. There could be no doubt that an enormous industrial development would take place in India and that a great local demand for timber would arise. Porto Novo, south of Madras, in which he had served, had been the site of an iron foundry, charcoal being used for the purpose. Both the iron and the charcoal had been sent down from the Ghats by the Cauveri River, the foundry being in Porto Novo. Whatever might have been the success of such an undertaking in Bengal, the only record of success in Madras consisted of the epitaphs of the great number of employees who died at the factory, the epitaphs being inscribed on cast iron tombstones made in the factory. He did not think much else remained of the industry but those tombstones. He had, however, used in Madras very excellent steel which was made by means of charcoal, and he thought a good deal might perhaps be done in the development of the manufacture of charcoal steel in the future.

Sir Bradford Leslie, in seconding the motion, said that a previous speaker had referred to the fact that in travelling through the length and breadth of India, the absence of timber was remarkable. That, he thought, was largely due to the denudation of timber for the purpose of providing fuel for the railways. Owing to the want of coal, huge tracts of timber had been cut down and it was very important indeed that those areas should be re-afforested. If that were done it would have an effect upon the climate, because every ton of timber grown neutralised the heat of the sun to the corresponding extent, and by tempering the climate the rainfall was increased and regularised. Where bare hills and rocks were exposed to the sun they got hot during the heat of the day and gave off that heat at night, thus preventing condensation of the moisture. Re-afforestation of denuded tracts was therefore a very important subject, to which attention should be paid.

The Chairman, before putting the resolution, announced that letters regretting their inability to be present had been received from Lord Crewe, Lord Novar, Sir John Stirling-Maxwell, and others. He was particularly sorry that Lord Novar and Sir John Stirling-Maxwell, had been prevented from attending, because he hoped they would be the champions of the Empire Forestry Association, to which Mr. Corbett had referred, and which was about to be launched. He ventured to appeal to all interested in forestry to do their utmost to help to place that Association on an influential footing.

The motion was carried unanimously and the meeting terminated.

NOTES ON BOOKS.

Soaring Flight. By Lt.-Col. R. de Villamil (late R.E.). London: Charles Spon. 1s. 6d.

In this interesting little pamphlet, Colonel de Villamil discusses a problem which has puzzled observers for many years: How can birds remain in the air for many hours and move at a fast pace without any apparent motion of their wings? In the plains of India, he mentions, vultures can be seen circling in the air for a whole day without wing motion. It is difficult to explain Colonel de Villamil's theory of this circling soaring flight without the diagram which he gives, but generally it may be stated that when the bird is moving with the wind it glides slightly downwards.

During this descent the wind is doing work on the bird, and thus increasing its energy. The bird then, by turning at right angles to the wind, changes, and increases, its speed relatively to the air. It then rises rapidly, converting its excess kinetic energy into potential energy of height. Turning later into the wind, its speed, relatively to the air, is further increased and its rise is still more rapid. Arrived at the highest point of its flight, it again turns down the wind, and repeats the operation.

Metaphorically, one may say that, when the bird travels down wind its "trap" is open but when it turns, the door of the trap closes, and the energy is securely "trapped."

By this means the pelican is described as rising to a height of 8,000 feet, without any exertion beyond that of steering.

A bird searching for food, however, only takes the amount of energy from the wind necessary to enable it to keep at one uniform level.

The wonderful flight of the albatross is also discussed at some length.

The Microscope. By Simon Henry Gage. Thirteenth Edition. Ithaca, New York: the Comstock Publishing Company.

Professor Gage's well known work on the microscope has now been revised for the thirteenth time. In his latest edition special attention has been devoted to Dark-field Microscopy, and a description is given of new apparatus designed to make its use more comfortable for the eyes. There seems to be no doubt that a wide field is opening out before this method of investigation.

At this time of day it is unnecessary to call attention to the merits of Professor Gage's work. They are familiar to all serious students of microscopy, who will find that the present edition contains all the advantages of former issues, including a valuable bibliography and index, together with excellent accounts of the latest improvements in the science and art of microscopy.

GENERAL NOTES.

THE COAL RESOURCES OF THE BRITISH EMPIRE.—At the present time the question of coal is of great importance, and it is fully recognised that the nations whose coal production is largest will be in a dominant position. The new publication of the Imperial Institute on this subject is, therefore, most opportune. It is the fifth of the series of monographs on mineral resources, with special reference to the British Empire, which are being issued under the direction of the Mineral Resources Committee of the Imperial Institute. It is written by Mr. J. H. Renaldson, M.I.M.E., and published by Mr. John Murray, price six shillings. The volume contains full information on the coal deposits of the Empire, localities being shown on twelve specially drawn maps. The geology of the deposits is fully described, and a large number of analyses of coal are recorded. The estimated reserves of coal and, in those countries where coal-mining is carried on, the statistics of coal production are recorded. There is an interesting description of the origin and growth of the coal industry in each country, and of the great progress made in the chief producing countries during the last 50 years, which is graphically shown by diagrams. There are also general tables giving the annual coal production for recent years of the principal countries of the world, their domestic consumption, imports and exports, and their actual and probable reserves; also a table of coal reserves shown by Continents, the British and Foreign totals being separately tabulated. The most important coal resources of the world are to be found in the Northern Hemisphere, and generally in countries near the Atlantic Ocean. Of these nearly three-fourths are in North America, chiefly in the United States, whose coal resources are about twenty times as great as those of Great Britain. The British Empire contains less than one-fifth of the total coal supplies of the world.

"KOKA SEKI" AND ITS USES.—"Koka Seki" is a variety of pumice stone which, so far as now known, is only found in the small group of Niijima Islands (New Islands), which lie off the coast of the Idzu Peninsula, about 90 miles south of Tokio. Though used in Niijima from ancient times as a building material, reports the U.S. Vice-Consul at Yokohama, only comparatively recently has "Koka Seki" become known commercially in Japan proper. Because of its durability, high tensile strength, and capability of resisting 1,300° C. of heat, it is suitable for boiler and furnace construction as well as inner linings of safes and the manufacture of ice chests. As it is claimed, it can be easily cut, will take a surface of paint or metal plating, and as nails can be driven into it, it is thought that the uses of this material will greatly increase. It is, however, in reinforced concrete barge building in Japan that it is best known. This concrete is stated to be about 60 per cent. lighter than the ordinary kind, and is said to be absolutely resistant to seepage, water erosion, or serious breakage by freezing and thawing. The current prices of "Koka Seki" in Tokyo are about 1 yen (2s.) per cubic foot for blocks, and 33 sen (about 8½d.) per cubic foot for flakes and sand. The only company at present dealing in this article is the Minamoto Kogyo Kabushiki Kaisha, 61, Akashi-cho, Kyobashi-ku, Tokyo.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

FEBRUARY 16.—WILLIAM CRAMP, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice." SIR JOSEPH E. PETAVEL, K.B.E., D.Sc., F.R.S., Director of the National Physical Laboratory, in the Chair.

FEBRUARY 23, at 4.30 p.m.—SIR DANIEL HALL, K.C.B., F.R.S., Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture, "The Present Position of Research in Agriculture." (Trueman Wood Lecture.) Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the Chair.

March 2.—CAPTAIN J. MANCLARK HOLLIS, Secretary to the Village Centres Council, "The Re-Education of the Disabled." Lord Henry Cavendish Bentinck, M.P., in the Chair.

MARCH 9.—

MARCH 16. — CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime." THE RIGHT HON. LORD JUSTICE ATKIN in the Chair.

INDIAN SECTION.

Fridays at 4.30 p.m.

APRIL 22.—LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

MAY 27.—WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

INDIAN AND COLONIAL SECTIONS.
(Joint Meetings.)

At 4.30 p.m.

FRIDAY, MARCH 18.—WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory

Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

TUESDAY, MAY 3.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

DR. C. M. WILSON, "Industrial Medicine."

PROFESSOR ARCHIBALD BARR, D.Sc., LL.D., M.Inst.C.E., "The Optophone."

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures.

Syllabus.

LECTURE I.—FEBRUARY 14.—Introduction—Classification of Catalytic Action—Theories of Catalysis—Technical Difficulties.

LECTURE II.—FEBRUARY 21.—*Processes of Oxidation.*—Sulphuric Acid—Nitric Acid—Chlorine—Catalysts in the Gas Industry—Sulphur Recovery—Surface Combustion—Incandescent Mantles—Organic Industries—Formaldehyde—Drying Oils—Linoleum—Oxidation of Hydrocarbons.

LECTURE III.—FEBRUARY 28.—*Processes of Hydrogenation.*—Preparation and Purification of Hydrogen—Methane—Hexahydrobenzol—Oil Hardening—Synthesis of Ammonia—the Cracking of Oils—Synthetic Rubber.

Hydrolytic Processes.—Saponification—Glucose—Alcohol—Acetic Acid—Acetone and Ether.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

MEETINGS FOR THE ENSUING WEEK *

MONDAY, FEB. 14..Post Office Electrical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Graduates' Meeting.) Sir John Dewrance, "Generation of Steam."

Electrical Engineers, Institution of (North-Eastern Centre), Armstrong College, Newcastle, 7.15 p.m. Mr. G. A. Juhlin, "Temperature Limits of Large Alternators."

Brewing, Institution of (London Section), at the Institute of Chemistry, 30, Russell Square, W.C., 8 p.m. 1. Mr. Jas. Stewart, "The Screening and Storage of Barley." 2. Mr. H. M. Lancaster, "The Screening and Storage of Malt." 3. Mr. F. A. Mason, "Insect Pests affecting Barley Growers and Maltsters."

Surveyors' Institution, 12, Great George Street, S.W., 7 p.m. (Junior Meeting). Mr. F. V. Bathurst, "Statutory Tenancies under the Increase of Rent and Mortgage Interest (Restrictions) Act, 1920."

Geographical Society, Kensington Gore, W., 5 p.m. Lt.-Col. E. A. Tandy, "The Crustation of the Earth's Crust."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. W. E. Willink, "The Cunard Building."

TUESDAY, FEB. 15..Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Eng.-Vice-Admiral Sir G. G. Goodwin, "Development of the Use of Oil in the Navy as a Boiler Fuel."

Statistical Society, 9, Adelphi Terrace, W.C., 5.15 p.m.

Metals, Institute of (Local Section), Imperial Hotel, Birmingham, 7.30 p.m. Dr. O. F. Hudson, "Bearing Metals."

Royal Institution, Albemarle Street, W., 3 p.m. Hon. J. W. Fortescue, "The British Soldier since the Restoration." (Lecture III.)

Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Dr. R. E. M. Wheeler, "Roman Colchester: New Materials, the Forum and the Town Plan."

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. W. B. Makins, "Paint Spraying."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. W. Thomas, "Picture Making on the Cornish Coast."

WEDNESDAY, FEB. 16..Meteorological Society, 70, Victoria Street, S.W., 5 p.m.

THURSDAY, FEB. 17..Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. F. Handley Page, "The Handley Page Wing."

Royal Society, Burlington House, W., 4.30 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Dr. W. A. Herdman, "Oceanography—(Lecture III.) The Sea Fisheries."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Prof. E. Wilson, "Magnetic Susceptibility of Low Order." Lecture I.—"Instrumentation."

Numismatic Society, 22, Russell Square, W.C., 6 p.m.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m.

Chromatics, International College of, Caxton Hall, Westminster, S.W., 8 p.m. Mrs. Ensor, "Colour in the Nursery."

FRIDAY, FEB. 18..Technical Inspection Association, at the SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m.

Royal Institution, Albemarle Street, W., 9 p.m. Mr S. Solomon, "Strategic Camouflage."

Metals, Institute of (Local Section), The University, Sheffield. Dr. F. Rogers, "Cracking in Worked Brass and other Metals."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Mr. F. M. Farmer, "The Desirability of Standardisation in the Testing of Welds."

SATURDAY, FEB. 19..Royal Institution, Albemarle Street, W., 3 p.m. Mr. A. Fowler, "Spectroscopy." (Lecture II.)

Announcements intended for insertion in the above list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

*For Meetings of the Royal Society of Arts see page 177.

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FRIDAY, FEBRUARY 18, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 21st, at 8 p.m. (Cantor Lecture.) ERIC K. RIDEAL, M.B.E., M.A., D.Sc., F.I.C., "Applications of Catalysis to Industrial Chemistry." (Lecture II.)

WEDNESDAY, FEBRUARY 23rd, at 4.30 p.m. (Ordinary Meeting.) SIR DANIEL HALL, K.C.B., F.R.S., Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture, "The Present Position of Research in Agriculture." (Trueman Wood Lecture.) Lieut.-Colonel The Right Hon. Sir Arthur Griffith-Boscawen, M.P., Minister of Agriculture and Fisheries, in the Chair.

TENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 9th, 1921; SIR FRANK WARNER, K.B.E., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Beere, Orlando George, London.
Bent, Arthur, Manchester.
Ellen, Alfred Edward, London.
Fussell, G. E., London.
Millard, Walter S., Tunbridge Wells.
Rice, Lieut.-Colonel Sidney Mervyn, C.I.E., O.B.E., Poona, India.
Vasavada, Mohanlal Vallabbji, Morar, Central India.

The following Candidates were balloted for and duly elected Fellows of the Society:

Andrews, Leonard Poel, London.
Nanton, Brigadier-General H. C., C.B., C.I.E., London.
Pinn, Herbert John Stewart, Bushey, Herts.
Procter, Sir Henry Edward Edleston, C.B.E., London.
Stapley, George, London.
Thomas, Roger, B.Sc., Baghdad, Mesopotamia.

An address on "The Possibilities for Improving Industrial Art in England" was delivered by PROFESSOR WILLIAM ROTHENSTEIN, Principal, Royal College of Art.

The address and discussion will be printed in a subsequent number of the *Journal*.

CANTOR LECTURE.

On Monday evening, February 14th, MR. ERIC RIDEAL, M.B.E., M.A., D.Sc., F.I.C., delivered the first lecture of his course on "Applications of Catalysis to Industrial Chemistry."

The lectures will be published in the *Journal* during the summer recess.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

EIGHTH ORDINARY MEETING.

WEDNESDAY, JANUARY 26TH, 1921.

MR. W. GREENWOOD, M.P., Vice-President, British Cotton Industry Research Association, in the Chair.

The paper read was—

THE ORIGIN AND DEVELOPMENT OF THE RESEARCH ASSOCIATIONS ESTABLISHED BY THE DEPARTMENT FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

By A. ABBOTT, M.A.

Assistant Secretary of the Department of Scientific and Industrial Research.

Nearly two years ago Sir Frank Heath read before this Society a paper on "The

Government and Scientific Research,'' in which he surveyed the whole field of the work of his Department, and included, in outline, that part of its work which is directed to encouraging the application of scientific research in industry. To-day, I propose to attempt to fill in this outline, and to extend and amplify his description, by giving some account of the origin and development of the Research Associations established under the Government scheme.

Since it is the object of Research Associations to maintain and increase the prosperity of the industries by which they are established, and consequently to add to the welfare of the nation as a whole, it may be worth while briefly to consider what are the foundations on which the industrial prosperity of the three greatest modern industrial States, that is, of Great Britain, the United States of America and Germany, has been based. This topic has been discussed very fully by Professor Alfred Marshall in his recent book on ''Industry and Trade.''

Our own country was the first to conduct industries other than agriculture on a large scale, with great aggregations of capital. It is often assumed by writers on industrial history that this was due mainly to the fact that the early inventors of textile and other machinery were natives of these islands. I believe that this assumption is only partly true, and that the chief reason for our early industrial development was the fact that this country, earlier than any other, had reached a stage of political and economic development favourable to the growth of a factory system.

Every country depends for its industrial welfare on the possession of certain material resources, which its geographical position, the character of its people, and its stage of political and economic development enable it to utilise. For centuries the main industry of this, and of every other country, had been agriculture, since the first need of man is that for food. All mechanical operations had been performed by the use of power supplied by man himself, by certain domestic animals or by wind or falling water: so long as the workers were not free to move from place to place, while there was little security for property other than land, there was no impetus impelling men to devote their attention either to utilising other sources of power or to devising machines which could be worked in groups and driven by a central motive power.

Towards the middle of the Eighteenth Century, however, the political condition of Great Britain had become favourable to the exploitation of her coal fields, and the conduct of industries on a large scale became practicable. After food, the most pressing need of a man in temperate climates is that for clothing, and, accordingly, the textile industries were the first to feel the new impulse towards centralisation. John and Robert Kay, Wyatt, Lewis Paul, Hargreaves, Arkwright, Crompton, and Cartwright all made mechanical inventions of first rate importance to the textile industries; the stationary steam engine was invented, and the Factory system came into existence. Simultaneously came the improvement of means of transport; roads were improved, canals were cut and railways were built for the carriage of both goods and men.

Not the least of our advantages was our geographical position, which gave, and still gives, to this country easy and convenient access both to the countries from which we draw our raw materials, and to the overseas markets which absorb our finished goods. Our material advantages would, however, have been of little avail if Great Britain had not possessed a sturdy, energetic and intelligent population.

At the time when Great Britain was passing through the throes of her Industrial Revolution, the population of the United States was entirely inadequate even to begin the task of exploiting her enormous natural resources; this was of necessity delayed until the Nineteenth Century was far advanced.

At this time, the French Revolution had not yet taken place, and the population of France consisted mainly of peasants attached to the soil of the landowners, and with little freedom to transfer their labour elsewhere. As Dr. Johnson observed on the one occasion when he visited the Continent, ''France had no middle rank;'' further, the country had before it a series of devastating wars.

Germany was still an unorganised group of separate States and Kingdoms, which were not welded into a coherent unit until after 1870.

In view of these facts, it is no matter for surprise that the Industrial Revolution took place here, and that this country was, consequently, the first to become thoroughly industrialised. For this reason, it became a national tendency for the Briton to look with a somewhat disparaging eye on the efforts of other countries to develop their industries; we forgot the favourable circumstances which had brought about our early success, and were inclined to think that only Britons were capable of inventing or of organising or carrying on industry. It is only in recent years that experience has taught us the truth, that an Englishman who does not put brains into his business is not so efficient as a foreigner who does. The proposition appears to be self-evident, but its truth is even yet not universally accepted.

Let us consider now the reasons for the swift industrial development of the United States and Germany.

The population of the United States differs from that of any of the European countries in two respects; in the first place, a very large proportion of it consists of unskilled immigrants from older countries, no less than 26,000,000 persons having entered the country during the last hundred years. In the second place, the needs of the great bulk of the hundred million citizens of the United States are fairly homogeneous. Under these circumstances, those industries have been developed in America in which a small number of highly skilled men can supervise large numbers of unskilled workers: and it is precisely these industries which can supply goods suitable for a market with homogeneous needs. Inevitably, therefore, the predominant characteristic of American industry is the mass-production by automatic or semi-automatic machinery of standardised goods which are distributed to a very large extent in the home market.

As regards Germany, she entered the contest for industrial wealth late in the day and with many disadvantages. On the one hand, she had not, like Great Britain, a skilled population, easy access to raw materials and overseas markets, and long experience of the needs of Colonial and foreign buyers; on the other hand, she had not, like the United States, enormous natural resources and a ready home market. How was she to set about her task? With what weapons was she to equip herself? There was only one way and only one weapon, and neither Great Britain nor the United States had ever found the way or tried the weapon. This was left to the rulers of industrial Germany, who made the most skilful and vigorous use of their complete realisation of the fact that "knowledge is power."

By every means at their disposal they added to their knowledge and thus increased their power, and their reward has been swift. The industrial progress of Germany between 1870 and 1914 is amazing to anyone who does not realise the potency of the means she employed to secure it. As the result of a well-considered policy, steadily pursued, she has become supreme in certain industries whose prosperity depends on a combination of wide and prolonged education with organised scientific research. In the task of carrying on research for the benefit of industry, she has made the fullest use of the capacity of the German for diligent, painstaking work and of his ability to work under capable direction as a loyal member of a team.

We are often inclined to blame this or that branch of industry for not having realised the value of new discoveries and for having allowed such discoveries to be exploited by foreigners. In this we are laying the blame on the wrong shoulders; it should properly be laid on the shoulders of those responsible for the neglect of education in this country, since it is only by education that the average man can have his imagination quickened into life; and without living imagination it is impossible to picture even faintly what the future will be like.

II.

When we had to engage in war with a well-prepared, skilful and energetic enemy we found it necessary to produce munitions of war in such quantities and at such a speed as had never been anticipated. We were, therefore, compelled for the sake of our national existence to follow the example of the United States and to manufacture by means of automatic machinery, under the most rigid conditions of standardisation and interchangeability, and with diluted labour, colossal quantities of the most varied munitions of war. The work

of our engineering shops had to be organised and carried on under conditions very similar to those American engineering shops which are engaged in the mass-production of standardised goods.

Again, Germany employed all the resources of science and all the skill of her scientific investigators to devise new means of attaining her end and compelling us to ask for peace on her terms; in order to cope with her and to shape appropriate defensive and offensive measures, we were compelled to direct greater attention to scientific research than ever before. Great Britain shewed in this respect also, that, although the oldest of all industrial countries, she was still young enough to adapt herself to the new conditions that had arisen and the fresh calls that were made upon her. By adopting methods of mass-production and standardisation, and by energetically applying scientific research to military and industrial problems, the war ended in our favour, but only after five most strenuous years. It is quite safe to say that if the same methods had been adopted earlier, and that if we had not relied on our national gift for improvisation, the war would have ended much earlier; perhaps even it would not have begun.

The lesson to be drawn from our experience is quite plain. It is that the same methods which enabled American and German industry to make such rapid progress during the last quarter of the nineteenth century and provided us with the means of winning the greatest war ever waged should not be allowed to fall into disuse, but should be fostered and encouraged by every legitimate means.

I am not concerned to-day with matters relating to mass production. My task is to describe to you a plan for giving fresh and more vigorous life to our industries by the systematic and continuous infusion of new knowledge gained by methods which have amply proved their worth in the time of our greatest need. We have still a great task before us, how great can scarcely be realised; but the knowledge that our total national expenditure during the period between 1914 and 1920 actually exceeded our total national expenditure during the two and a quarter centuries between 1688 and 1914 gives us some notion.

III.

At a very early stage of the War the British Government saw clearly the direction in which our industries must move if we were to maintain our national prosperity, and accordingly in 1915 they established a Committee of the Privy Council to make arrangements for encouraging the application of science to industry. By the end of 1916 the scheme was sufficiently advanced to justify the Government in setting up the present Department of Scientific and Industrial Research, and in placing at its disposal a capital sum of a million pounds for the purpose of making grants to Industrial Research Associations, established in accordance with the conditions laid down.

This country was the first to adopt measures of this kind. Its example has been followed by Australia, Canada, South Africa, Belgium, France, Italy, Japan, Norway, Sweden, and the United States of America; the movement for the organisation and encouragement of scientific research with a view to utilising in the best way possible the materials and forces at the disposal of mankind may therefore be described as world wide. In no two of these countries are the schemes identical; and this is natural, since each country must frame its plans in harmony with its traditions and in accordance with its needs and conditions.

It was the swift development of mechanical inventions and the rapid growth of industry that enabled our predecessors to free themselves from the debt incurred during the long Napoleonic Wars. To look forward to new inventions for gaining some relief from the burden of debt that lies so heavily upon us at the present time is therefore not unreasonable. But epoch making inventions cannot now be made by unlearned men, working alone and with slender means. At this stage in our industrial history they can usually only be made by trained men, working in well-equipped laboratories, with full access to existing knowledge and with ample resources: often indeed when the task is complex, they can only be made by teams of workers directed by men of the widest knowledge and most varied experience. It is for this reason that the encouragement given by the British Government to industrial research has assumed its present form. The scheme was not formulated until after the most careful consultation both with men of science and with manufac-

turers. The plan of entrusting the whole task of aiding industrial research to existing institutions, such as the Universities, the great Technical Colleges and the National Physical Laboratory, and allocating to each of them a definite part in a comprehensive scheme of national research for the benefit of industry, was considered. This plan had undoubtedly many attractions and obvious advantages, since it involved mainly the extension of existing laboratories, the enlargement of the present nucleus of trained men experienced in research, and the bridging of the gap that at present separates these institutions from some of our industries; moreover it could have been started at once.

There were, however, serious difficulties in the way of its adoption. In the first place, the handing over to the Universities of the main responsibility for conducting industrial research would have had the immediate effect of diverting chiefly to utilitarian ends the attention of men whose first aims usually are to increase the amount of human knowledge without any regard whatever to its possible commercial value, and to train young men and women in the methods of acquiring and utilising knowledge, whether new or old. Not only would these aims have been narrowed or obscured, but the liberty of the University Professor to choose his own subject of investigation and to carry out his work in the way that seemed best to him, would have disappeared, as he would often have had to subordinate his desires and intellectual interests to the consideration of whether the research on which he was engaged was likely to be useful or not for a particular purpose specified by an external organisation.

Further, since our modern Universities are situated in the midst of districts whose industries are many and varied, the complexity of the task placed before each of these Universities of providing adequately for the needs of the district they served would have been enormous, and might well have led to the entire destruction of the primary function which they were established to perform.

The most serious obstacle to entrusting the responsibility for the conduct of industrial research to existing institutions faces us, however, when we regard the the question not from the standpoint of the Universities, but from that of the industries. It is quite certain that knowledge supplied from an outside organisation, however efficient, can never be of the same value to industry as the knowledge gained by industry itself. What industry needs is a thorough knowledge of the fundamental principles underlying its practice and an ability to apply this knowledge. It can never gain this knowledge and acquire this ability if it is accustomed to rely on a constant stream of information poured into it from outside sources. The only way in which it can acquire intellectual independence is through the successful pursuit of knowledge for itself. This consideration is decisive, and consequently the whole scheme is based on the necessity for delegating to industry the organisation and prosecution of the scientific investigation of its materials, processes and plant. On these grounds the Government decided therefore to encourage separate industries to organise themselves for the purpose of carrying out research co-operatively. With this object they instituted the present scheme for the establishment by industries themselves of non-profit sharing Companies, registered under the Companies Acts, and having powers to carry on research and to aid education. These Companies are known as Research Associations.

To such Associations as are approved by the Department of Scientific and Industrial Research, a grant from the Million Fund is made annually for a period of five years. At the end of that time the grant ceases.

There is some reason to believe that the financial arrangements between Research Associations and the Research Department are not always completely understood, even by persons who take part in discussions relating to them, and for this reason it appears desirable that they should be briefly described.

In the first place, if British industries had realised years ago the value to themselves of scientific research, the grant of a huge capital sum by Parliament would not have been necessary; the industries would have organised research without any State grant and would have seen that it was properly and efficiently carried out. The purpose of the grant is not to maintain over an indefinite period co-

operative schemes of research: its purpose is to demonstrate by actual experiment that money spent with proper care by industries on the scientific investigation of their technical problems is not a mere speculation which may or may not yield results of value, but, with reasonable care and diligence, provides a safe and remunerative investment. In other words, the grant is intended to educate and stimulate; that is all.

Since it would be sheer waste of money sorely needed for many other national purposes to make a grant for a period insufficient to test the value to an industry of the work of a Research Association, the Government scheme demands that before any grant becomes payable to an Association arrangements shall be made for the continuance of the work for five years.

Again, it would be waste of money and effort for an industry to embark on a scheme of research with an income obviously insufficient to carry out a comprehensive scheme. Accordingly, the Department, before completing any arrangements for paying grant, requires that a certain absolute minimum income shall be raised by the Research Association concerned. This minimum income depends on the nature of the industry, and consequently differs from Association to Association. Against this income the Department makes a grant of pound for pound; further, in order to allow for the natural expansion of the work during the period of grant, the Department has hitherto agreed to pay at this rate on the income raised by Research Associations between the absolute minimum laid down and a somewhat higher annual income. To take an example; in the case of several Research Associations, the promoters have agreed with the Department that it is not worth while to begin the work with a smaller total annual income than £5,000 and that before the end of five years the total annual income necessary may be £10,000. It has therefore been arranged that the grant from the Department shall be one pound for every pound of income raised from the members of the Association between £2,500 and £5,000 a year. In the early days of the scheme the Department made agreements for additional grant to be given at a rate lower than pound for pound when the income of the Research Association exceeded the higher of the two limits laid down. In view of the existing commitments out of the Million Fund, this course is no longer possible, but the payment of additional grants to Associations raising income in excess of that which formed the basis of agreement will of course be considered if funds are still available.

A good deal of consideration has been given by the different Research Associations to the methods of raising income from their members and, as might have been expected, the basis of assessment varies from industry to industry. It is obvious that three considerations must be borne in mind in deciding what basis of assessment shall be adopted; (*a*) the yield must be fairly constant from year to year, (*b*) the basis must be such that it can be ascertained readily, (*c*) different branches of the same industry must have comparable assessments.

The amount of capital employed in the business, the output, the wage bill, the number of workpeople employed, flat rates and voluntary contributions with a fixed minimum are all taken as bases of assessment by different Associations, and so far the arrangements made have proved satisfactory. The fact is that in the majority of industries the actual subscription of a member of a Research Association is an extremely small charge on his business, especially when one remembers that it is regarded by the Board of Inland Revenue as a "business cost" to be deducted from profits before Income Tax and Excess Profits Duty are calculated.

In some cases, the subscription paid by firms is smaller than the premium against fire insurance, though loss by fire is an uncertain risk, while loss through ignorance is as certain as death.

IV.

The financial assistance granted temporarily to industries to enable them to establish on a permanent basis the organised scientific investigation of their numerous problems, forms only one part of the help that can be given to them by the Department of Scientific and Industrial Research.

No scheme, however well planned, can be efficiently carried out unless there is an adequate supply of trained men available. In the past the rewards offered to research workers in industry have not been great and the demand for such workers has been comparatively small. How are Research Associations to be staffed? It is obvious

that this problem is very pressing, since the staffing of Research Organisations by second rate men would inevitably result in the failure of the scheme. Indeed the result would be even more far reaching, since it would delay or possibly prevent altogether the employment of research workers by individual firms on anything like the scale that the conditions of British industry demand. From its formation, the Research Department has adopted means for increasing the supply of trained research workers, not only for Research Associations, which are, after all, only one type of Research Organisation, but for other agencies for research in pure and applied science. The number of skilled research workers before the war was not excessive, and during the war the Universities were necessarily denuded of students.

It is in order to meet the general need for men and women trained in research that the Department devotes annually a considerable sum of money from the Parliamentary Vote to the provision of Post-graduate Studentships for students recommended by their Professors as being suitable for training. It is expected that many of these students will, on the completion of their training, devote themselves to scientific investigation. If they enter the service of Research Associations, so much the better for the Associations. Even if they devote themselves to teaching, they will surely find that their experience in gaining new knowledge will be of some value to them in the task of imparting old knowledge. Unless these trained students find that scientific investigation furnishes for them careers comparable with the careers of students of similar qualifications who go into other occupations, the supply will naturally diminish and our last state will be worse than our first. The fact that the supply of trained workers competent to undertake research in such subjects as Botany, Entomology and Mycology is quite inadequate for the needs of the industries depending for their raw materials on the development of tropical agriculture is, at such a time as this, very disquieting.

Up to this point I have spoken only of "industrial" research. You are familiar with the fact that when the Government established a Research Department, the scheme was for the encouragement of *scientific* and *industrial* research. Both words are used, since, although all research must be scientific, there is research which is not of immediate industrial importance. Why should the Government scheme include provision for encouraging research in pure science apart from utilitarian objects? The reason is that industrial research cannot exist unless there is also research in pure science, that is, research aimed solely at the extension of the boundaries of human knowledge entirely apart from any consideration of the possibility of utilising that knowledge for industrial ends. It is the function of the Universities to make such additions to knowledge as are within their powers and to ensure that the newly gained knowledge is freely available to all who can make use of it. Unless this function is adequately performed, industrial research workers will starve for lack of proper nourishment; it is absolutely necessary that they should be fed from a common stock of knowledge which is being continually replenished and placed at their disposal without stint.

Accordingly, when the Government undertook to aid industrial research its action was based on the belief that its assistance would be of little value unless research in pure science was also aided. Provision is, therefore, made by the Department of Scientific and Industrial Research for enabling men of science to continue individual investigations, whether these have any industrial bearing or not: hitherto most of the investigations aided in this way have had, so far as can be judged, only a theoretical interest. Again, it is universally recognised nowadays that knowledge gained in one branch of science is, or may be, of value to other branches of science; and similarly, knowledge gained primarily for the benefit of one industry may be of equal or, in some cases, of greater value to another branch of industry with which the first appears to have little or nothing in common. The national organisation of scientific research must, therefore, bring each scientific worker into some relation to the whole body of science; it must also bring each Research Association into some relation not only to all other Research Associations, but to all the agencies engaged in fostering or conducting scientific research. This demands organisation, and especially does it demand whole-hearted and harmonious co-operation, since the organisation must be of such a character that it involves, not the loss of originality

intellectual independence or individuality by the workers, but an increase in their productivity.

With a view to securing co-operation amongst research organisations connected with the Research Department, a "Records Bureau" has been established to serve as a clearing house of information, and it appears likely that this will serve a most useful purpose. In order that the organisation may not be too cumbrous, it has been decided that it shall deal only with the work of bodies connected with the Department. To the Records Bureau is entrusted the task of examining all programmes of research which are received in the Department, in order to find out whether it is necessary to call the attention of the senders to work already done or in progress by other bodies. Similarly, all results of research go to the Records Bureau in order that arrangements may be negotiated for transmitting results gained by one organisation to another to which they appear likely to be of value. I want to make it quite clear that all results sent to the Department by Research Associations are regarded as confidential; they are never communicated to persons or firms eligible for membership of a Research Association who have not thought fit to join one; and they are only communicated to other industries or other Research Associations or other Government Departments on proper terms after consultation with the Association which has obtained them.

V.

I have discussed at length the grants which the Department of Scientific and Industrial Research makes to Research Associations, the method in which it trains research workers, the steps it takes to encourage research carried out by individuals and the scheme it has formulated for enabling Research Associations to draw from a common pool of knowledge. What does the Government expect to get in return for the public funds expended in this way? The answer to this question is that the knowledge gained will be utilised for national purposes. In some cases, the results of research will be communicated directly to other industries by the Records Bureau under the conditions I have already described. In other cases they will be utilised directly by Government Departments after proper arrangements have been made. The result of establishing Research Associations for separate industries will, therefore, not be to enrich certain sections of the population to the exclusion of others at the public cost; it will be to increase the efficiency of all industries which need greater knowledge of the principles underlying their practice and to enable Government Departments to obtain more quickly and at smaller cost the results of the scientific investigations they need for the public service.

When the scheme for aiding industrial research was under consideration, it was found that certain great industries could not conveniently be dealt with by Research Associations, since their welfare is of pressing importance not mainly to sections of the population, but to every individual in these islands. Every industry and every household is concerned in the efficient and economical use of fuel; every individual is a consumer of food. Since the investigation of methods of using fuel and of preparing and preserving food are of such universal importance, it was decided that it should be undertaken by the State at its sole cost, and accordingly a Fuel Research Board and a Food Investigation Board were established, these being followed at a later period by the setting up of a Building Research Board. It is anticipated that the results of the work of these Boards will be of great value, not only for the primary object which they have in view, but also for the supplying of industries generally—usually through Research Associations—with knowledge which they can utilise. For example, it already appears probable that the work of the low temperature Research Station to be established for the use of the Food Investigation Board at Cambridge will afford valuable knowledge to the Research Associations concerned with the investigation of heat problems.

One of the problems that the Research Department and the industries have had to face has been the grouping of industries into Research Associations. It has been found that the only satisfactory method of doing this has been to leave it mainly to the industries themselves, after giving them, of course, full information as to the conclusions drawn from the previous experience of the Department in attempting to solve the problem. If a group of men, thoroughly representative of an industry or of a group of industries, approach the

Department of Scientific and Industrial Research and say that they wish to form a Research Association for their industry, the Department inquires whether they have a common interest in research; if it is found that they have, then the question of grouping is regarded as settled. Naturally, in the early days of the Department, mistakes were made—not only by the Department, but by representatives of industry. For example, attempts were made on several occasions to group together *makers* and *users* of the same goods; these attempts were unsuccessful, and it was concluded that makers and users would not readily combine for the common purpose of research. Then arose other instances, in which makers and users did combine, and it became necessary to look into the matter more closely in order to find out what factors, if any, had been overlooked. It was then found that makers and users will combine, if they do not stand to one another in the ordinary relation of buyer and seller; if the price is fixed by individual bargaining between buyer and seller, then it is useless to try to get them to combine, but if the price is a market price arrived at as the result of a number of bargains, then there is no obstacle to combination between maker and user for the purpose of research.

At the present time the number of Research Associations which have been approved by the Department and licenced by the Board of Trade is twenty-three, the list being as follows:—

The British Boot, Shoe and Allied Trades' Research Association.
The British Cotton Industry Research Association.
The British Empire Sugar Research Association.
The British Iron Manufacturers' Research Association.
The Research Association of British Motor and Allied Manufacturers.
The British Photographic Research Association.
The British Portland Cement Research Association.
The British Research Association for the Woollen and Worsted Industries.
The British Scientific Instrument Research Association.
The Research Association of British Rubber and Tyre Manufacturers.
The Linen Industry Research Association.
The Glass Research Association.
The British Association of Research for the Cocoa, Chocolate, Sugar Confectionery and Jam Trades.
The British Non-Ferrous Metals Research Association.
The British Refractories Research Association.
The Scottish Shale Oil Scientific and Industrial Research Association.
The British Music Industries Research Association.
The British Leather Trades Research Association.
The British Launderers' Research Association.
The British Electrical and Allied Industries Research Association.
The British Silk Research Association.
The British Motor Cycle and Cycle Car Research Association.
The British Cutlery Research Association.

You will notice in some cases the group of industries constituting the Research Association is very complex, this being most noticeable in the case of the textile Associations. The British Cotton Industry Research Association, for instance, includes spinners, manufacturers of cloth, lace and hosiery goods, bleachers, dyers, calico printers and finishers: it makes provision also for the inclusion of cotton growers. However complex the group may be, there is in each case a real community of interest in scientific investigation.

Certain industries appear unlikely to form Research Associations, and this for various reasons:

(*a*) if the normal economic unit is very large, there is no probability that a Research Association will be established, since such a unit has resources which enable it to carry on its own research. No suggestion has ever been made, for instance, that the manufacturers of heavy chemicals or of iron and steel should establish Research Associations;

(*b*) if the normal economic unit is very small, the difficulty of establishing a Research Association is considerable. This difficulty has, however, been overcome in the case of the Cutlery Trade, and is likely to be overcome by the Pottery Manufacturers;

(*c*) the industry may employ such a small amount of capital in this

country that it cannot afford to carry on a scheme of co-operative research. In such a case as this, the industry is likely to disappear from the country unless it has very favourable conditions either of labour or of raw materials or of markets;

(d) the industry may not depend on scientific knowledge for its welfare. Quite a number of industries fall into this group: some of them depend for success on the artistic quality of their goods, others on manual dexterity, and others again on the use of machines produced by the engineering industry. Examples are goldsmiths' work, tailoring and dress-making, millinery, beer-bottling.

Up to the present no Research Association has been formed to deal with general engineering. The reasons for this are not quite clear, but I would suggest that the omission of the Engineering industry to form a Research Association may be due to some or all of the following characteristics of the industry:—

(a) The industry has a large number of branches, differing in nature, and consequently community of interest in research is lacking.

(b) The very large Engineering firms carry out research for themselves.

(c) Engineering has been taught in Universities and Technical Institutions for a long period, and there is a constant influx into the industry of trained men, capable of solving minor problems.

(d) The practice of Engineering is based on the laws of Mechanics and of Physics and Chemistry; the former have been known for generations, while the Universities, both in this country and abroad, have carried out a vast amount of research on those parts of Physics and Chemistry which have a bearing on Engineering problems. It is not without significance that it is only the newer branches of Engineering, that is, Cycle and Motor Car construction and Electrical Engineering that have formed Research Associations to deal with their particular branches of this important industry.

There is another great group of subsidiary industries for which the Research Association as established does not seem suitable. Every industry uses accessory materials for whose investigation its Research Association cannot be expected to make adequate provision until it has dealt with its major needs. How to deal with these accessory materials is uncertain: it may be that the best course will be to have them investigated by a group of interested Research Associations; or possibly the Department itself, which is concerned with research needed by other Government Departments, will in some cases find it desirable to undertake the work.

There is another question about which it is desirable that I should say something; that is, what is the relation of the Government to each Research Association?

I can answer this best by quoting from the Conditions of Grant:—"Subject to these conditions, and to the Statutory and other duties laid upon Research Associations by the conditions of grant, it is the intention of Government that the conduct of the affairs of the Association shall be in the hands of the Association itself." This is, I think, quite clear. Many of you are, no doubt, quite familiar with the relationship which exists between the Board of Education and Local Education Authorities, and it will be an almost complete explanation to such persons to say that the relation of the Department to approved Research Associations *during their period of grant*, is almost identical with that of the Board of Education to Local Education Authorities.

Thus the Research Association elects its own Council (though the Department reserves the right to appoint a small proportion of the members), appoints its own officers, frames its own programme of research, and carries out its scheme in its own way. It may not, however, spend more than a certain proportion of its income in any single year of the period of grant on buildings or permanent equipment without the sanction of the Department; it must satisfy the Department that research is being duly prosecuted, and every year it must furnish the Department with a report and a balance sheet, whether it is in receipt of a grant or not. If it is receiving grant, this is obviously necessary; if it is not, it must still submit a balance sheet and report, since the Department has undertaken the responsibility of certifying to the Board of Inland Revenue that its expenditure is on research.

VI.

When a Research Association has completed the steps necessary for its formation and recognition by the Department, its next business is to appoint a Council of management, and the necessary Committees, co-opting such representatives of science and of industry as it may consider desirable. In every case Research Associations hitherto established have co-opted men of science to aid their Councils in their deliberations; in a number of cases they have co-opted also representatives of skilled labour, in order that labour may be informed as fully as possible of the objects of the Association.

One of the conditions laid down by the Department is that a Research Association shall at all times have a Director of Research, who will be responsible to its Council for the whole of its research work. It is his duty to prepare, in consultation with the appropriate Committees, a complete survey of the whole of the field of research, covering the ground for, say, five years ahead; his next task is to prepare a programme of work for the first year. What can be done during the first year is conditioned by two factors (*a*) what are the most pressing and important matters for investigation? (*b*) what men and facilities are available?

It is always recommended by the Department that existing institutions, such as Universities and Technical Colleges, shall, as far as possible, be utilised. At the start, they will certainly be used by most Associations, and it is desirable that they shall, so far as is consistent with their other duties, be used permanently. It is probable, however, that sooner or later, nearly every Research Association will find it necessary to set up a Research Institute of its own, this step already having been taken by at least eight Associations for the purpose of carrying on work which either cannot conveniently be undertaken in existing institutions or is unsuitable for them. The fear has been occasionally expressed that the establishment of Associations for co-operative research will reduce the demand for the services of scientific men inside mills and works. Experience shews, however, that the effect of establishing Research Associations has not been to diminish but actually to increase the number of scientific men employed by firms which have joined Research Associations. These organisations are new, and it is impossible to forecast accurately what form their activities will take, but it is most satisfactory to find that the present tendency of Research Associations is towards the investigation of fundamental principles, and the prosecution of research only to the initial point of practical utility, the industrial firms being left to work out the methods of applying the new knowledge to their own particular problems.

It is worthy of note, that the attitude towards their work of many men engaged in industry has changed since they began to envisage the effect which the scientific investigation of their every-day problems may have. Instead of looking upon their daily visits to their works as a necessary but dreary task, which must be faced if they are to make a living, they are finding a real interest in their business, and are devoting their attention to increasing its efficiency and the welfare of everyone connected with it by scientific research. They are realising that it is not merely the end of the journey, but the journey itself that is worth the trouble. A very great English man of action—Oliver Cromwell—said: "To be a Seeker is to be of the best Sect next to a Finder: for such a one shall every humble, faithful Seeker be at the end." Of the truth of this there can be no doubt. Patience will be needed, as results of value are usually slow in coming. It would be just as reasonable to expect a coal mine to pay a dividend from the day on which the first sod was cut as to expect a Research Association to make discoveries of commercial value before it has had time to survey its field of research, and investigate thoroughly some portion of that field. It is quite certain, however, that if Research Associations choose the right men, equip them suitably and set their faces in the right direction, lasting benefit will result, not only to the industries concerned, but to the nation as a whole.

DISCUSSION.

THE CHAIRMAN (Mr. W. Greenwood, M.P.), said he was sure all those present would agree that they had listened to a very comprehensive paper, which showed that the author had given a great deal of thought to its preparation and thoroughly understood the subject with which it dealt. Some time ago a certain works in Lancashire had considerable difficulty with one of its engines. The old engineer had left some time before and a younger man had taken his place, and the difficulty could not be overcome.

It struck the managers and directors of the works that it would be a good thing to ask the old engineer to come back and see what he could do. He came back and very soon put the matter right, and his bill of costs read: "To 10 hours at so much an hour, so much," and at the bottom: "£10. Total: £12 7*s.* 6*d.*" He was asked what the item of £10 was for, and his reply was: "That is for knowing how." That was really the reason why research should be encouraged—so that people could get to "know how." It could not be expected that everybody would appreciate anything that the Government had done, but he believed that at any rate the most enlightened section of the public would appreciate the work the Government had done with regard to the encouragement of the establishment of Research Associations. He did not think any money the Government had spent had been so wisely spent as that which had been devoted to the establishment of those Associations, and yet no money had been spent of which it could so truthfully be said that no return from it could be absolutely certain in a short time. Of nothing more than of research could it be said, "Cast thy bread upon the waters for thou shalt find it after many days." The experience the cotton industry had had of the assistance of the Government with regard to the formation of its Research Association had been a very happy one indeed. He was very glad to see that Sir Frank Heath, who had had a great deal to do with the inception of the Research Associations, was present that afternoon. A debt of gratitude was also owing to the author for the work he had done in that respect, and so long as the inauguration of the Research Associations was in the hands of those gentlemen, he was certain that the money allocated by the Government would be very wisely spent indeed. There were very many reasons why the Research Associations should be supported. He would have been glad to see a larger attendance that afternoon, but he thought it might be assumed that those who had come to listen to the paper were really converted disciples of research, and that they would help to make many more people just as interested in that very important subject as they were themselves. No industry ever refused to insure against ordinary losses by fire, breakdown of machinery, loss of profits, and so on, but a great many industries seemed to think there was no necessity to insure against loss of knowledge. Therefore, all industries ought to be encouraged to take up research, wherever possible, in the most scientific manner. It might be said that, owing to the great industrial depression now being experienced in the country, the present time was inopportune for such research, but he thought the reverse was the case. Just now, when people said, "Why don't you try to improve your business and make it as scientific as possible in every way?" one might reply: "That is all very well, but first of all I want to be able to run my business ordinarily before I can begin to think about any specific means of improving it;" but still it must be admitted that industry had its ebbs and flows, and those engaged in it must be ready for the brighter future which must certainly come, and which it was hoped would not be very long in coming. He trusted that those present would try to interest others in the very great problem of research. It was difficult to convince ordinary people of its necessity, and it was therefore all the more important that those who did realise the imperative necessity of dealing with research should do all they could to bring over to their own way of thinking those who might perhaps be termed, without any disrespect, "stick-in-the-muds" with regard to trade and industry.

Dr. Arthur W. Crossley, C.M.G., F.R.S. (Director, British Cotton Industry Research Association), said he had very carefully read the various documents issued by the Department for Scientific and Industrial Research, and was totally in sympathy with its aims and objects in the establishment of Industrial Research Associations—otherwise he would not have taken over the responsibility of attempting to direct the activities of one of them. So heartily was he in sympathy with their establishment that he had no criticisms to offer on the paper. From what he had seen in the North of England he was convinced that there was plenty of room for research, and there was a very receptive spirit abroad on the part of those who formerly were less willing to support research. He was heartily in sympathy with the movement, and thought sincere thanks were due to the author for setting forth so clearly the aims and objects of the Research Associations.

Mr. W. H. Sugden, M.P., said he could not add anything to the very admirable suggestions made by the author. Research had a very important bearing on the Government of the country, because he thought the employee should have an equal opportunity with those who provided capital for industry in determining the factors of the same. In the uncertain and peculiar conditions now prevailing, both in regard to home production and in regard to international competition, it was vital that the finest opportunities in respect to business management should be proffered to, and the most scientific formulæ in respect to industry should be in the possession of thoroughly efficient and educated employees, so that they might co-operate with the employers in securing the finest production and output that were possible in the many and varied industries of the country. Speaking for Lancashire, he thought a spirit of *camaraderie* was being established in the textile industries between the leaders of labour and the employers, and personally he hoped that spirit would spread abroad,

so that in other industries besides the textile industries that breadth of opportunity and outlook might get into the minds and thoughts of some of the "stick-in-the-mud" Departments of the Government, more especially in respect to those who were supposed to be controlling and guiding industry. It was often difficult to support the Government when one remembered the retrogressive fashion in which Government officialdom was thwarting and cramping industry and the progress of industry, and he hoped those present who represented the employing section of industry would, supported by the employees, press home on the Board of Trade and other Government Departments the vital and essential point, not of municipalising or nationalising industry, but rather of making more efficient the individualism in industry which had built up the trade and commerce of this country and which, given its opportunity by the careful research which had been so admirably described by the author, would lead and guide industry to a future which at the present time could hardly be conceived. He desired, in conclusion, to express his thanks to the author for the very helpful suggestions made in the paper.

Mr. H. Weeks said he would not have attended the present meeting unless he was interested in Research Associations generally, and more especially in the one with which he was connected, and he was afraid he could not add anything useful to the discussion. He was in entire agreement with everything the author had said in the paper.

Dr. J. A. Harker, F.R.S., said his object in attending the meeting was to learn something more than the little he already knew about the Research Associations that had been established by the Department for Scientific and Industrial Research, and that the author had dealt with, but there was one point on which he might say a few words. He thought Mr. Abbott was perfectly right in saying that there was a new attitude current in well-informed circles towards research. For the past four and a half years he had been looking after a definite branch of research for the Ministry of Munitions, and he had been very much struck by the fact that at all times, day and night, and on Sundays as well, he had been rung up by all kinds of people, chiefly connected with Government Departments, who required immediate answers to questions on scientific subjects. In some of those cases it had been quite a pleasure to him to have at hand books and other sources of information which enabled him to answer such questions at once. There was a new attitude being adopted towards research in those Government Departments which had been alluded to as some of the most typical "stick-in-the-mud" Departments. He had that morning received an enquiry—the answer to which had already been despatched—on a perfectly definite scientific problem, from a Department which perhaps would be a successful candidate for the prime place among those labelled "stick-in-the-mud" by some of their critics. He thought the war had certainly had a very important effect in making people, whose chief technical work was perhaps something quite different but who had incidentally to deal with very important scientific matters, take a much more serious view of those matters, and not regard them as subsidiary side-lines which had to be attended to in some spare moment, if possible, but which they looked upon all the time as more of a nuisance than anything else. He had been impressed lately by the conspicuous ability of technical officers, whose main work was perhaps not definitely scientific, but to whose duties had been attached all kinds of scientific problems as one of their subsidiary activities, and they had been devoting a very great amount of attention to those matters. He thought there was very clear evidence of a new attitude and a much greater inclination to assess those things as of great importance on the part of the type of individual to which he had referred. That was a hopeful sign, and it meant that the lessons taught by the war were not being altogether forgotten. In many cases a much more sympathetic attitude was being adopted towards the man of science in high places in Government circles.

Mr. J. W. Williamson said he wished to express his appreciation of the author's admirable paper, which viewed the whole problem from a wide angle and to a far horizon. He thought it was most important that those engaged in the research movement should do everything they could to spread abroad a really correct idea of the nature of research, not merely amongst manufacturers, but also amongst the Press. As the Secretary of a Research Association he received a visit not very long ago from a representative of one of the big London daily papers who professed himself greatly interested in the research movement, and almost the first question he asked was: "Have you got out any sensational results yet?" It seemed that at present the main interest of the Press in this research movement was to have something which would lend itself to sensational headlines. That idea had to be destroyed and a long view of research substituted for it. With regard to the story told by the Chairman of the engineer who charged £10 for "knowing how," the function of research work was not merely to enable people to "know how" but also to "know why." If the engineer in question had been able not only to remedy the defect, but also to show why that particular remedy was effectual, he would have been entitled to charge at least another

£100. With regard to the paragraph in the paper dealing with the provision made by the Department with respect to Research Associations, formed and to be formed, that not more than a definite proportion of the income of any year must be spent on what might be called capital expenditure in the way of equipment, he would like to point out that that proportion must naturally vary with the nature of the Research Association. It might happen in the case of some industries that the whole of the income of the first year might well be spent on equipment. It had to be remembered that most industries started Research Associations without any capital at all, and the only funds they had available for capital expenditure were derived from income. Some Research Associations, such as the Cotton Research Association, had solved the problem by raising an independent fund, but not all industries could do that, and it therefore seemed to him that, since in order to start an Association a large initial expenditure might be necessary, it might well be that the proportion decided upon by the Department should be very much greater in the first year than in subsequent years. There was one other point he would like to raise. When a Research Association had been founded, when it had got to work and had begun to produce results, it would probably be found that it was not sufficient to circulate those results to the members of the Association. If an individual commercial firm had produced, for instance, some product which was superior in many respects to existing products for the specific purpose in question, that firm would not be content with merely publishing the fact; it would engage in the work of publicity and propaganda and in commercial "push" to create a demand for its product. The Research Associations had not got the funds or the organisation for such commercial propaganda or commercial "drive," and yet there were many cases in which the result of research might be of the utmost importance, but merely to put the result before the members of the Association might not be sufficient to secure its wide and general adoption. There was in certain cases a great deal of inertia to be overcome. It might be that a product was of value to a particular firm, but the existing methods were such that the firm, in the absence of any severe competition, could manage to get along without adopting new methods, especially when the new methods might mean the scrapping of older methods. It was therefore worth while for the Research Associations to consider to what extent they might have to develop what might be called commercial pressure, in order to secure that the results of their researches were transferred into the workshops of the industry.

Mr. L. Gaster said he thought the Department for Scientific and Industrial Research ought to be congratulated for having created so many Research Associations. He would like to ask the author if there was any likelihood of the annual grant from the Department's fund of a million pounds, which was to be made to Research Associations for a period of five years, being renewed. He would also like to know what was the position of the researcher, the young student who was brought into contact with Research Associations. What income was to be given to him for any patent or invention carried out by him? Personally he thought such a man should be encouraged by some *pro rata* award being given to him for any invention he made. He was very glad indeed that the National Physical Laboratory had been taken over by the Research Department. Nothing was more distasteful than to think that a national institution such as that had to live from hand to mouth. In 1905 it was his privilege to visit the Laboratory and to write an article for the "Times Engineering Supplement" on its need for subscriptions. The fact that the National Physical Laboratory was now financed by the Research Department meant that many experiments could be conducted there without any fear that the cost of them could not be met. He thought the Research Department ought to be thanked for that.

Mr. A. Abbott, in replying to the discussion, said that with regard to the question asked by Mr. Gaster as to whether the grant of a million pounds would be renewed, that sum was granted by Parliament as a lump sum, the object of which was to stimulate and carry on an experiment for a limited period of time. Parliament did not promise to give any more and one could not tell what any succeeding Parliament would do. There was certainly no promise or guarantee that the grant would be renewed. With regard to the reward to the inventor, that was one of the most difficult questions to decide, but he thought that, generally speaking, the principle ought to be that a research worker should be paid an adequate salary with a small commission, rather than that he should be paid a small salary and a very large commission. The chief point was that the research worker should be paid an adequate salary. If the reward to the inventor were made very large because of an invention which he made, that might tend to prevent the necessary fundamental research being carried on. If one man working in a laboratory made an invention which brought him a large sum of money, then other people in the laboratory might wish to follow his example, and research might be directed to immediate utilitarian ends, with the result that the necessary fundamental investigations were neglected. Further, it was very seldom in these days that an invention was made by a single man. The tendency was for it to be made by a team of workers.

On the proposition of THE CHAIRMAN, a hearty vote of thanks was accorded to Mr. Abbott for his interesting paper, and the meeting terminated.

CORRESPONDENCE.

THE FUTURE OF INDUSTRIAL MANAGEMENT.

As an industrial manager having experience in several countries, I desire to make one or two observations on Mr. Lawson's paper, which appeared in the *Journal* of the 14th inst.

The point on which he seems to lay most stress is that there was comparative peace and willing service in the Merchant Service, and that it was due to the fact that the employers (Captains) have "gone through the mill;" but the Boards of Directors of shipping companies are no more trained through seamanship up to their posts than are those of any other business. The officers immediately responsible for running the ship are so trained and naturally on that account command respect, if their own personal characters are right, but Mr. Lawson might as well have asked how it was that the Army did its bit so well. In my opinion the answer is, in both cases the same, *i.e.*, discipline. The great majority of Britons will fight and work for the love of it, or because of a fine sense of duty, but, unfortunately, there are black sheep in every fold, and disciplinary laws have to be made to stop the rot in minorities, which otherwise would soon permeate the whole community.

At sea or on board ship a strike is a mutiny and is dealt with very sharply. The same is true of the Army, and in both cases failure to act promptly and strongly would endanger the lives of the whole unit. In industry the same danger is not so apparent, but it exists. The frequent resort to strikes is largely due to panic or vote catching legislation having placed on the Statute Book laws permitting peaceful picketing, which is only another name for intimidation; picketing is (apparently) peaceful only because the worker knows full well that resistance to wordy persuasion would inevitably lead to physical compulsion. These facts have long been understood, but the moral courage to move for the deletion of the pernicious clause has been lacking till perhaps it may be too late. We hear much of the right to work, but that right is denied only by the Trade Unions, whose tyranny has been substituted for that of the Masters, which, indeed was only sporadic, whereas the new tyranny is universal and continuous.

Other qualities, besides a practical working knowledge (invaluable although this is) are required in industrial management, and all the qualities are rarely found combined in one person. If there were no other way to reach the position of director than that desired by Mr. Lawson, I fear the effect would be disastrous for our industries. One of the merits of American conditions is that a man may freely move from one industry to another and so find his own true level. The fine results are obvious.

In these days of immense factories with many processes in progress under one roof, it is nearly impossible for one man to be thoroughly trained in each, but Boards of Management usually contain all the elements necessary to the successful conduct of the business. They must, however, be able to obtain the same loyal service which is exacted in the Merchant Service or in the Army, and which is in no way incompatible with humane treatment and reasonable consideration of the feelings and aspirations of the workers.

I submit then that the first necessity is to repeal the clause sanctioning peaceful picketing and to make Trade Unions amenable to the ordinary laws of the land, thus restoring their lost freedom to the workers.

J. MELROSE ARNOT.

NOTES ON BOOKS.

BRITAIN VICTORIOUS! A PLEA FOR SACRIFICE. By M. de P. Webb, C.I.E., C.B.E., late Chairman, Karachi Chamber of Commerce, and Additional Member, Bombay Legislative Council. Second Edition London: P. S. King & Son, Ltd. 1920.

The purpose of this reasoned little work, the author tells us, is "to recall the great Law of Sacrifice—the key to all human progress—and to point out that only by a practical recognition of this law, only by a renunciation of the attempt to extract from war conditions even greater wealth than could be engineered in times of peace can Britain expect to win through to a victorious, progressive future."

The chief sacrifice he advocates relates to War Loan scrip, amounting to £7,000,000,000 and involving an annual expenditure of £300,000,000 to £350,000,000 in the shape of interest, a sum, he points out, as large as, if not larger than, the nation's yearly savings in pre-war times. He appeals with much earnestness to the people of Britain to show their patriotism in these days of storm and stress by foregoing the "equivalent of one half of their holdings" in these securities—he mentions £200,000,000 as the figure to be aimed at—so as to reduce the colossal National Debt, which like a mill-stone hangs about the taxpayer's neck and helps to check reconstruction. Failing voluntary action, "sacrifice"—he so terms it—"by compulsory monetary service, or forced levy, must," he insists, "be carried out by Government." Shortly before the appearance of the present edition, the House of Commons refused

to adopt the idea of a capital levy or an appropriation of "war fortunes." Sir Montagu de P. Webb—his useful public activities in India have just brought him the honour of Knighthood—says that the debate on the occasion referred to "sent a chill to the heart of many outside Parliament." It would be out of place to discuss here general levies, State Control, and other controversial topics embraced in Sir Montagu's survey, but it may be noted that the well-known banker, Mr. F. C. Goodenough, in addressing the shareholders of the great institution of which he is chairman, recently made the following remarks, apparently with the assent of his listeners:—"Now that we see the conditions which prevail to-day we can realise how fortunate it was that the steps at one time contemplated by the Treasury for a levy on capital values were not carried into effect. If they had been the consequences would have been serious indeed." It is only fair to say that the levy Sir Montagu recommends would be one confined to wealth not employed productively and exempt the "great volume of British industry, agricultural and manufacturing, transporting, financing, marketing for export." Even with these exemptions there is, he emphatically declares, no physical impossibility in collecting a contribution of £4,000,000,000 towards the repayment of the National Debt.

The book is very appropriately dedicated to the munificent anonymous benefactor who the year before last sent £150,000 of 4 per cent. Funding Loan to the Chancellor of the Exchequer for cancellation.

THE YOUNGEST PUNJAB CANAL COLONY. Lahore: Printed by the Superintendent, Government Printing, Punjab. 1920.

This brightly-written pamphlet should be widely distributed in the United Kingdom, where the magnitude of the irrigation works that are bestowing so much material benefit upon a considerable portion of our Indian fellow-subjects is not as fully realised as it deserves to be.

The "youngest Punjab Canal Colony" is a large tract known as the Lower Bari Doab, which ten years ago was nothing but a dreary waste, and is to-day a richly fertile country. The "canal" itself is one hundred-and-thirty miles in length, while there are a thousand miles of distributary channels and eight thousand miles of water courses. It formed part of the great "Triple Canal Project" described by Sir John Benton in the paper he read before the Society in 1913 (Vol. LXI., p. 717), and receives its supplies of water from the Chenab, which is compensated for what it could not otherwise afford by the tapping of the more distant Jhelum, the only northern Punjab river with any surplus to spare.

A portion of the reclaimed land is allotted to officers and men of the Indian Native Army in reward for distinguished military service, and a third is reserved for ordinary peasant cultivators on condition that every tenant of a twenty-five acre holding keeps a mare for the provision of remounts. The colony has become a most important horse-breeding area. Another interesting feature is the allotment of farms to a very loyal class, the landed gentry "whose prosperity has not kept pace with the growing wealth of the middle-classes and the peasantry." The "Depressed Classes," about whom we have heard so much in connection with the Montagu-Chelmsford reforms, are afforded an opportunity of rising from the menial position to which their hereditary occupations have condemned them; while a small fraction of the population, about one in five hundred, consists of criminal tribesmen, who occupy separate villages under certain restrictions. The prospect of occupancy rights has reconciled them to these restrictions, and it is gratifying to learn that very few are tempted to break away to the old vagabond life.

The prosperity of the Lower Bari Doab is derived mainly from cotton and corn. In an average year the sale of the former brings in two million pounds; the income from wheat is over a million.

GENERAL NOTES.

POPULATION OF JAPAN.—According to figures recently published by the statistical bureau of the Imperial Cabinet, the population of Japan as a whole, showed an increase on December 31st, 1918, of 2,950,000 over the number reported December 31st, 1913, or a total of 58,087,277. The population is largely centred around the industrial districts, and in thousands of small villages in alluvial plains, rural valleys, and along the sea coast. The industrial trend of Japan is reflected from the facts that the growth was most extensive in the industrial prefectures, while some of the rural prefectures more distant from industrial centres showed a decline. The density of the population, which is greater for its effective agricultural area than that of any other country, averages 390 per square mile. Tokio's population of 2,347,442 gives a density of 2,011 per square mile, and while, owing to the low height of building prevalent in Japan, this figure is not high for a modern city, the density in many chiefly agricultural districts in which the urban population is largely confined to villages, ranges from 600 to 1,200 per square mile. For instance, Kagawa prefecture, with a population of 714,000, of which only 106,000 live in towns of over 10,000 inhabitants, is practically entirely agricultural, and yet has a density of 1,054 per square mile. The combined population

of Tokio and its suburbs totalled 3,279,545, and next in size was Osaka proper, with a population of 1,641,580.

VEGETABLE OIL IN BURMA.—The annual production of vegetable oils in Burma (which has varied little since 1913), is about 60,000 tons, or 16,000,000 gallons; that of oil cake is about 50,000 tons. The yield of oil per ton of raw material crushed is about 30 per cent.; that of oil cake 60 to 65 per cent. In Lower Burma paddy husks are generally used as fuel. The cost is nothing or negligible. In Upper Burma wood is generally used. It costs about five rupees per ton. There has been practically no change in the cost of wood since 1913, excepting that resulting from the rise in the value of the rupee.

SCHOOL OF MINING AND GEOLOGY FOR INDIA.—The Government of India are establishing a School of Mining and Geology at Dhanbad, Chota Nagpur. The school, which it is intended shall rank with similar institutions in Great Britain, will be Imperial in character, but the Provinces are to be represented on the Governing Body, and it is hoped that the provincial Governments as well as associations representing industries, will give liberal support in the way of scholarships and lectureships. The Supreme Government are also considering the establishment of a metallurgical institution at Sakchi-Jamshedpur, as recommended by the Holland Industrial Commission.

TRADE IN INDIAN OIL SEEDS.—The report of the Indian Committee of the Imperial Institute on the trade of India in oil seeds, just published by Mr. John Murray, shows that the total annual production of oil seeds of all kinds in India is probably well over 5,000,000 tons in quantity and £50,000,000 in value; in normal times, approximately one-third of the output is exported. No other country produces in commercial quantities so great a variety of oil seeds. Of the ten chief of these, viz., linseed, ground nuts, cotton seed, rape seed, castor seed, sesame seed, copra, mowra seed, poppy seed and niger seed, India supplies no less than 30 per cent. of the total amount entering commerce. Before the war, about one-third of the total quantity of oil seeds exported from India came to the United Kingdom, the chief kinds being cotton seed, linseed and castor seed. Certain other oil seeds, such as ground nuts, sesame, copra and mowra, were shipped mainly to France, Germany and Belgium. Various suggestions are made by the Committee with a view to extending the trade in Indian oil seeds with the United Kingdom, and developing the British oil seed crushing industry. It is considered that a free choice of the raw material produced within the Empire should be secured for this industry, if necessary by a system of rationing and licensing in the producing country. If further assistance is required, an import duty should be imposed on oils and fats of all kinds imported to the United Kingdom from foreign countries. The Committee consider that the latter method would be more satisfactory than a preferential export duty on Indian oil seeds. A memorandum on the effect of import tariffs on the oil seed crushing industry, by Mr. J. W. Pearson, Chairman of the Seed Crushers' Association of the United Kingdom, is appended to the report.

"ALCOBRONZE."—*The Engineer* reports the invention and testing of a new alloy of copper and aluminium by the Aktiebolaget Skandinaviska Armaturfabriken. It is called "alcobronze"; it has the colour and lustre of gold, and is said to be stronger, tougher and harder than any other bronze. It is further stated that it can be wrought, forged or rolled in any way without suffering deterioration, and that it resists the action of the air, acids and salt water, being, therefore, particularly suitable for ships' forgings, propellers, condensers, machine parts, bearings, surgical instruments, skates, ornaments, etc.

THE JAPANESE NAVY AND OIL FUEL.—According to the *Osaka Mainichi Shimbun*, the Japanense Navy Department some time ago gave an order in Great Britain for 200,000 tons of petroleum per annum, but the order was declined owing to the shortage of supplies. The order was then sent to America, but was again declined. This has dislocated the Japanese Government's Naval plans, as it makes it dependent on the home supply of oil, which is quite inadequate.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

FEBRUARY 23, at 4.30 p.m.—SIR DANIEL HALL, K.C.B., F.R.S., Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture, "The Present Position of Research in Agriculture." (Trueman Wood Lecture.) LIEUT.-COLONEL THE RIGHT HON. SIR ARTHUR GRIFFITH-BOSCAWEN, M.P., Minister of Agriculture and Fisheries, in the Chair.

March 2.—CAPTAIN J. MANCLARK HOLLIS, Secretary to the Village Centres Council, "The Re-Education of the Disabled." Lord Henry Cavendish Bentinck, M.P., in the Chair.

MARCH 9.—

MARCH 16. — CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the

Investigation of Crime." THE RIGHT HON. LORD JUSTICE ATKIN in the Chair.

INDIAN SECTION.

Fridays at 4.30 p.m.

APRIL 22.—LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

MAY 27.—WILLIAM RAITT, F.C S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

INDIAN AND COLONIAL SECTIONS.
(Joint Meetings.)

At 4.30 p.m.

FRIDAY, APRIL 15.—WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire." The Right Hon. Lord Moulton, G.B.E., K.C.B., F.R.S., LL.D., in the Chair.

TUESDAY, MAY 3.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

DR. C. M. WILSON, "Industrial Medicine."

PROFESSOR ARCHIBALD BARR, D.Sc., LL.D., M.Inst.C.E., "The Optophone."

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures.

Syllabus.

LECTURE II.—FEBRUARY 21.—*Processes of Oxidation.*—Sulphuric Acid—Nitric Acid—Chlorine—Catalysts in the Gas Industry—Sulphur Recovery—Surface Combustion—Incandescent Mantles—Organic Industries—Formaldehyde—Drying Oils—Linoleum—Oxidation of Hydrocarbons.

LECTURE III.—FEBRUARY 28.—*Processes of Hydrogenation.*—Preparation and Purification of Hydrogen—Methane—Hexahydrobenzol—Oil Hardening—Synthesis of Ammonia—the Cracking of Oils—Synthetic Rubber.

Hydrolytic Processes.—Saponification—Glucose—Alcohol—Acetic Acid—Acetone and Ether.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

MEETINGS FOR THE ENSUING WEEK.*

MONDAY, FEBRUARY 21.. Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Lt. Col. F. A. Molong, "Prophecy."
East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Sir John G. Cumming, "Crime and Police in India."

TUESDAY, FEBRUARY 22.. Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m.
Royal Institution, Albemarle Street, W., 3 p.m. Dr. A. Keith, "Darwin's Theory of Man's Origin (in the light of Present Day Evidence)." (Lecture I.)
Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m. Mr. P. Allan, "Port Improvements at Newcastle, N.S.W."
Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. D. Charles, "Improvements in Flashlight."
Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m.
Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8 p.m. Dr. G. C. Creelman, "Agricultural Development in Ontario."

WEDNESDAY, FEBRUARY 23.. British Academy, at the Royal Society, Burlington House, W., 5 p.m. Professor E. de Sélincourt, "Keats."
Geological Society, Burlington House, W., 5.30 p.m.
Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. (Students' Meeting.) Mr. J. H. Barker, "Machinery Applied to Mass Production."

THURSDAY, FEBRUARY 24.. Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Discussion on "The Use of Light as an Aid to Publicity." 1. Captain E. Stroud, "Shop Window and Spectacular Lighting." 2. Mr. E. C. Leachman, "Illuminated Signs."
Diesel Engine Users' Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 2.30 p.m.
Royal Society, Burlington House, 4.30 p.m.
Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Miss Alice Werner, "The Wakilindi Saga."
Royal Institution, Albemarle Street, W., 3 p.m. Mr. F. B. Browne, "Mason Bees." (Lecture I.)
Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Professor E. Wilson, "Feebly Magnetic Materials" (Lecture II.)
Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr. E. S. Andrews, "Methods of Securing Impermeability in Concrete."

FRIDAY, FEBRUARY 25.. Technical Inspection Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m.
Royal Institution, Albemarle Street, W., 9 p.m. Dr. J. Buchan, "The American Civil War."
Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

SATURDAY, FEBRUARY 26.. Royal Institution, Albemarle Street, W., 3 p.m. Mr. A. Fowler, "Celestial Spectroscopy." (Lecture III.)

Announcements intended for insertion in the above list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the meeting.

*For Meetings of the ROYAL SOCIETY OF ARTS, see page 191.

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FRIDAY, FEBRUARY 25, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 28th, at 8 p.m. (Cantor Lecture.) ERIC K. RIDEAL, M.B.E., M.A., D.Sc., F.I.C., "Applications of Catalysis to Industrial Chemistry." (Lecture III.)

WEDNESDAY, MARCH 2nd, at 8 p.m. (Ordinary Meeting.) CAPTAIN J. MANCLARK HOLLIS, Secretary to the Village Centres Council, "The Re-Education of the Disabled." LORD HENRY CAVENDISH BENTINCK, M.P., in the Chair.

CANTOR LECTURE.

On Monday evening, February 21st, DR. ERIC RIDEAL, M.B.E., M.A., F.I.C., delivered the second lecture of his course on "Applications of Catalysis to Industrial Chemistry."

The lectures will be published in the *Journal* during the summer recess.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 16th, 1921; SIR JOSEPH E. PETAVEL, K.B.E., D.Sc., F.R.S., Director of the National Physical Laboratory, in the Chair.

The following Candidates were proposed for election as Fellows of the Society:

Dyson, William, Rotherham.
Garrett, J. D., London.
Hart, T. C., B.A., Dominica, B.W.I.

The following Candidates were balloted for and duly elected Fellows of the Society:

Barnes, Herbert Rushton, St. Petrocks, Llandudno.
Lombard, Norman, San Francisco, U.S.A.
Milward, Charles Frederic, J.P., Alvechurch, Worcestershire.
Sinclair, John H., New Glasgow, Nova Scotia.
Wood, H. A., Santa Elena, Argentina.

A paper on "Pneumatic Elevators in Theory and Practice" was read by Mr. WILLIAM CRAMP, D.Sc., M.I.E.E.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

COLONIAL SECTION.

TUESDAY, FEBRUARY 1st, 1921.

SIR DANIEL HALL, K.C.B., F.R.S., Chief Scientific Adviser and Director-General of Intelligence Department, Ministry of Agriculture, in the Chair.

THE SECRETARY OF THE SECTION read a letter from Dr. J. G. Adami, C.B.E., F.R.S., Vice-Chancellor of the University of Liverpool and formerly Strathcona Professor of Pathology and Bacteriology, McGill University, regretting his inability to be present to show his appreciation of the work accomplished by Dr. Creelman at Guelph. "It would," Dr Adami added, "be well if some Institute here in England could accomplish the great work for agriculture that has been accomplished by the Ontario Agricultural College. What Canada owes to Dr. Creelman and his predecessors at Guelph is very great."

THE CHAIRMAN, in introducing the reader of the paper, said that Dr. Creelman, as they had heard, was at one time head of the Agricultural College of Guelph, the oldest Canadian Agricultural College, and one which had left its mark not only on Canada but on the greater part of the United States. Guelph had always been the great centre at which the live-stock men not only of Canada but even of the United States had been trained.

The paper read was:—

"MODERN AGRICULTURE, WITH SPECIAL REFERENCE TO PROGRESS IN CANADA SINCE CONFEDERATION IN 1866."

BY G. C. CREELMAN, LL.D., B.S.A.,
Agent-General for Ontario.

As the whole process of food production is largely mechanical, it is comparatively easy for the individual to make a living

out of the soil. There have, however, been dark years of famine affecting whole continents, causing widespread destruction of life and rendering useless millions of dollars' worth of property. This is hardly possible now, because of the opening up of the New World; because of the easy transportation of food stuffs; and perhaps more especially because of the improvement of farm machinery. The grain reaper alone may be credited with moving all civilised people out of the "Bread Line," and raising the whole struggle for existence to a higher plane.

To-day, when the human race is growing wheat at the yearly rate of ten bushels per family, we can hardly believe that until recently the object of all nations was to get bread; that life consisted in a search for food. Yet it is not exaggeration to say that, leaving out rulers and their retinues, the human race was hungry for ten thousand years. Even of the black bread, burnt and dirty and coarse, there was not enough to go round. Merrie England was famine-swept in 1315, 1321, 1369, 1438, 1482, 1527, 1630, 1661 and 1719. Great nations fought for empire, for fame, for religion, for the protection of their homes, and thought these things of first importance. No one seemed to realise that "the first thing is bread."

From this side of the "self-binder," one of the most baffling things in all history is the slow growth of agriculture. In the British Museum, in a certain glass case in the Egyptian galleries, may be seen a little group of farm utensils—a fractured wooden plough, a rusted sickle, two sticks tied together with a thong of leather and some tassels that had hung on the horns of the oxen. To be sure, these were used three thousand years ago—they were found in the tomb of Seti I.—but one remembers that when Egypt was using these bread tools she had the most elaborate Government, an army and navy, and art and literature. Thousands of years afterwards the Pilgrim Fathers in America farmed with hoes and sharp sticks only. Within the memory of men and women now living there were wheat bounties in Maine and bread riots in New York City. Starving men fell in the streets of Boston and Philadelphia. Then came "improved" farm implements—sickles and flails and wooden ploughs were thrown away. Sulky ploughs and gang ploughs, and steam ploughs, and now gasolene ploughs, are found everywhere. Because of reapers and binders and threshing machines and motor trucks and railroad and steamship lines, America alone consumed last year twenty thousand million loaves of bread.

The history of Canadian agriculture since the Provinces united in 1866 is a romance. In the open prairie country, frosts have had to be reckoned with year after year. In British Columbia the huge timbers have had to be removed. In the Maritime Provinces the late springs have been a drawback, while in Ontario and Quebec, clearing off the forests, the erection of suitable buildings, draining and fencing the land, have meant much hard labour and constant sacrifice.

Will Carleton, in one of his "Farm Festivals," put these words in the mouth of one of his characters:—

"It ain't the funniest thing a man can do—
Existing in a country when it's new:
Nature—who moved in first—a good long while
Has things already somewhat her own style,
And she don't want her woodland splendour battered,
Her rustic furniture broke up and scattered,
Her paintings, which long years ago were done,
By that old splendid artist-king, the Sun,
Torn down and dragged in Civilization's gutter,
Or sold to purchase settlers' bread-and-butter;
She don't want things exposed, from porch to closet,
And so she kind of nags the man who does it.
She carries in her pockets bags of seeds,
As general agent to the thriftiest weeds:
She sends her blackbirds, in the early morn,
To superintend his fields of planted corn;
She gives him rain past any duck's desire—
Then, may be, several weeks of quiet fire;
She sails mosquitoes—leeches perched on wings—
To poison him with blood-devouring stings:
She loves her ague muscle to display,
And shake him up, say, every other day:
With careful, conscientious care, she makes
These travellin' poison bottles, rattlesnakes;
She finds time, 'mongst her other family cares,
To keep in stock good wild cats, wolves and bears:
She spurns his offered hand with silent gibes,
And compromises with the Indian tribes,

For they who've wrestled with his bloody art,
Say Nature always takes an Indian's part ;
In short, her toil is every day increased
To scare him out, and hustle him back East,
Till finally, it appears to her some day,
That he has made arrangements for to stay ;
Then she turns round, as sweet as anything,
And takes her new-made friend into the ring,
And changes from a snarl into a purr;
From mother-in-law to mother, as it were."

What love stories might be written of the pioneer days, could one but peep into the log houses of the backwoods fifty years ago. The health and contentment; the sound sleep that came after heavy toil; the intense satisfaction of driving back the giant forests and redeeming the fertile soil; the gradual growth of flocks and herds; the meeting of friendly neighbours through the ever-disappearing forests, as field met field, north and south and east and west. "Every bush was a battle-field and every field a victory."

To-day we have thoughtless youth calling the fathers fools for ruthlessly destroying the beautiful timber of the early settlement days. But timber was the pioneer's greatest menace. His object was to make a home and to supply food and clothing for himself and his family. The more trees he could destroy the more land he had available for wheat and barley and oats and potatoes. So he chopped and slashed and burned, with the result that the men of the present generation have splendid farms, well watered; and with an excellent climate, with plenty of sunshine and an adequate rainfall, good crops are assured year after year.

Field Crops.

Wheat.—To put "first things first," one must start with wheat. The growth is shown in the following Table :—

Year.	Acres.	Bushels.
In 1870 . .	1,646,781	16,722,873
In 1880 . .	2,366,554	32,350,269
In 1890 . .	2,701,246	42,223,372
In 1900 . .	4,224,542	55,572,368
In 1910 . .	8,864,514	132,077,547
In 1915 . .	15,110,000	393,543,000

The steady but rapid growth of this important cereal has meant much to the material prosperity of Canada. Besides feeding the Canadian people, it helps to build up great implement factories, and, by supplying large quantities of wheat for export, gives Canada a favourable balance of trade in Europe. The immense leap forward in 1915 was due to two causes. In the first place, a great patriotic wave swept over the country when Lord Kitchener predicted a "three years' war," and though the farms were very much depleted of labour by reason of so many men having joined the forces, yet the farmers worked as they never worked before, and planted the largest acreage in Canadian history; in the second place, the season was favourable for wheat, and, as shown above, 393,543,000 bushels were harvested. Wheat means to a country not only bread, but stock food of the highest value. Bran and shorts and middlings are almost indispensable for the raising of live-stock. Cattle and pigs especially do well on mill feeds, so that much flour means also more beef and more pork. And yet we are but started. Three hundred and two million acres are fit for tillage now, while fifty-one million acres only are under crop.

Oats.—Second only in importance among Canadian field crops is oats. In 1870, Canada produced 42,489,453 bushels, and in 1915, 464,954,000 bushels. Besides exporting millions of bushels of oats to England and France during the War, millions of bushels were also made into flour and meal as substitutes for wheat in bread-making that more wheat might be shipped to the allied countries. Many people who had been great meat-eaters found out, for the first time, the real values of cereals as human food. In a bulletin issued by the Ontario Agricultural College in 1916, a comparison was made of relative food values, and oats were put at the top; that is to say, if the value of oats is put at 100, wheat should be put at 92, corn meal at 91, rice at 62, white bread at 58, skim milk at 46, potatoes at 36, cheese at 19, mutton chops at 16, roast beef at 10, and eggs at 5. Thus, at the prices which then prevailed, a dollar's worth of rolled oats contained as much food as twenty dollars' worth of eggs, or ten dollars' worth of beef-steak.

Barley.—In 1870, Canada produced 11,496,068 bushels of barley, and in 1915, 54,017,000 bushels.

Shifting of the Grain Growing Area.

One remarkable feature of the fifty years' growth of Canada since Confederation is the shifting in the geography of grain growing In 1870, 85 per cent. of

the total crop of wheat was raised in Ontario. To-day more than one-half the crop is grown in Saskatchewan alone, and 92 per cent, in the three Prairie Provinces. Those Provinces also produce 77 per cent. of the barley and 64 per cent. of the oats.

There is in Canada a steady increase of grain per acre. This is no doubt largely attributable to the work of the Experimental Farms, Agricultural Colleges and Seed Growers' Associations. In Ontario, for instance, if the last thirty-six years is divided into two periods, there is an increase in yield per acre for the past eighteen years over the former period of 10 per cent. in oats, 14 per cent. in wheat, and 20 per cent. in barley. In comparing the average yield per acre of the several Provinces of wheat, oats and barley, it is found that in New Brunswick there is a slight increase between the two decennial periods of half a bushel for wheat, and two-fifths of a bushel for oats. In Manitoba and Saskatchewan, the wheat yield shows a decline, due perhaps to decrease of fertility through continuous growth of grain. In the case of oats, the average in Manitoba is less for the second period by 2.2 bushels, but the third period shows an increase of 4.8 bushels over the second period, and 2.6 bushels over the first period. For barley, in Manitoba the rate has increased by 2.3 bushels as between the first and third periods. For the five years 1913-17, in Manitoba the wheat yield is three-tenths of a bushel more; but oats show a decrease of 3½ and barley a decrease of 5.2 bushels as compared with the period 1903-1912. In Saskatchewan, oats increased by 2.9 bushels, and barley by 3.3 bushels. In Alberta all three crops increased, wheat by 1.8 bushels, oats by 1½ bushels, and barley by half a bushel. In Ontario there has been a distinct improvement in the average rate of production of the chief cereals. Although the difference between the first and second decennial periods is but small, the third period, compared with the first, shows that the average yield per acre of fall wheat increased by 3½ bushels, spring wheat by 2 bushels, barley by 4½ bushels, and oats by 1½ bushels. Expressed in terms of value, and calculated upon the area and prices of 1917, these extra yields represent for wheat $4,589,255, for barley $1,884,420, and for oats $2,901,960, or a total value of $9,372,635, due to the increased yield per acre in Ontario alone. While allowance may be made for causes other than improved skill in cultivation, such as, for instance, a decreased total area involving withdrawal from a particular crop of inferior land, it is reasonable to infer that improved methods of cultivation, including the use of better seed, have been the main factors in the progress indicated.

Because the Census is taken only at decennial intervals, it is impossible to make satisfactory comparisons of the yields per acre. There is no doubt, however, that the average yields at the present time are higher than they were at Confederation. In 1870 the yield of wheat in Ontario did not exceed 10.5 bushels per acre, whilst for the ten years 1902-1911 the yields were, according to the Ontario Bureau of Industries, 23 bushels for fall wheat, and 17.9 bushels for spring wheat, and the decennial average for 1908-1917, according to the Census Office estimates, was 23 bushels for fall wheat and 18¼ bushels for spring wheat. Other crops show a like progress. Crop returns for Canada compare favourably with the average yields of other countries, especially those countries where, like Canada, the areas devoted to grain are large and the cultivation is of extensive rather than intensive character. The following Table shows the average yield per acre of wheat, barley and oats in the principal grain-growing countries of the world, compared with the decennial averages for the period 1908-1917, as recently calculated by the Census and Statistics Office for Canada:—

AVERAGE YIELD PER ACRE OF WHEAT, BARLEY AND OATS IN SELECTED GRAIN-PRODUCING COUNTRIES OF THE WORLD.

Country.	Wheat.	Barley.	Oats.
	Bush. per Acre.	Bush. per Acre.	Bush. per Acre.
United Kingdom .	31·82	35·13	48·55
CANADA	19·25	27·00	35·25
Australia . . .	11·00	18·96	21·25
New Zealand . .	29·29	34·94	45·13
India	11·45	...	...
United States . .	14·72	24·91	28·08
Argentina . . .	9·52	15·06	22·04
Austria* . . .	20·37	28·25	34·38
Belgium* . . .	37·32	51·49	64·20
Bulgaria* . . .	13·68	19·52	19·42
France* . . .	19·93	25·46	33·85
Germany* . . .	30·78	36·80	49·86
Hungary* . . .	17·40	23·42	28·60
Italy	14·72	16·17	25·72
Rumania . . .	16·21	17·84	23·09
Russia in Europe* .	10·56	34·57	20·99
Spain	13·38	20·82	21·25
Denmark** . .	33·66	33·99	37·06

NOTE.—The above averages are calculated over the decennial period 1907 to 1916, except for certain countries marked with an asterisk *, for which the decennial data are incomplete. For Canada the period is 1908 to 1917. **Complete figures for Denmark 1908-17 are not available; the averages given are for the four years 1912, 1915, 1916, 1917.

A further measure of the progress made by Canada in agricultural production is obtainable by comparing the acreage and yield of crops per 1,000 of the population. This is done in the following table for field crops in the aggregate, and for wheat, oats, and hay and clover separately, for each of the census years 1870, 1910, and for 1915 and 1917 :—

ACREAGE AND YIELD OF CANADIAN CROPS PER 1,000 OF THE POPULATION, 1870-1917.

Year.	Field Crops.	Wheat.		Oats.		Hay and Clover.	
	Acres.	Acres.	Bush.	Acres.	Bush.	Acres.	Bush.
1870. . . .	...	472	4,797	...	12,189	1,047	1,095
1880. . . .	...	561	7,675	...	16,724	1,058	1,199
1890. . . .	3,268	564	8,809	826	17,406	...	1,605
1900. . . .	3,713	794	10,442	1,008	28,485	1,229	1,475
1910. . . .	4,794	1,230	18,325	1,200	33,792	1,149	1,568
1915. . . .	4,937	1,906	47,465	1,457	58,647	993	1,338
1917. . . .	5,095	1,764	27,596	1,592	48,201	983	1,636

Taking the total under field crops, the area has grown from 3,268 per 1,000 of the population in 1890 to 5,095 in 1917. For wheat, the area has grown from 472 acres per 1,000 in 1870 to 1906 acres in 1915, and 1,764 acres in 1917. Wheat production, which was 4,797 bushels per 10,000 in 1870, attained to 47,465 per 1,000 in the prolific year 1915, and to 27,596 in 1917. Oats grew from 12,189 per 1,000 in 1870 to 58,647 in 1915, and 48,201 in 1917. Hay and clover alone show a decrease as regards acreage and only a slight increase as regards yield. For area, the rate of 1,047 acres in 1870 has decreased to 983 acres in 1917, and the yield which was 1,095 short tons in 1870 and 1,605 tons in 1890, was not more than 1,636 tons in the good hay year of 1917.

The following table gives a comparison of the total areas and total values of field crops for the years 1910 to 1917 so far as data are available for the purpose :—

TOTAL AREAS AND VALUES OF FIELD CROPS, 1910-1917.

Year.	Areas.	Values.	Year.	Areas.	Values.
	Acres.	$		Acres.	$
1910	30,556,168	384,513,795	1914	33,436,675	638,580,300
1911	35,261,338	597,926,000	1915	39,140,460	825,370,600
1912	35,575,550	557,344,100	1916	38,930,333	886,494,900
1913	35,374,930	552,771,500	1917	42,602,288	1,144,636,450

The total area under field crops has grown from 30,556,168 acres in 1910 to 42,602,288 acres in 1917, an increase of 12,046,120 acres, or 39 per cent. To a large extent this increase was due to a wonderful output of farming energy during the War, and the results have been achieved by a population, whose growth was arrested through the decline of immigration, and whose force was diminished by the large proportion of the flower of Canadian manhood fighting overseas. In the same period the total value of the field crops of Canada has grown from $384,513,795 to $1,144,636,450, that is to say, the value in 1917 was nearly three times that of 1910. This result, no doubt, is due chiefly to high prices since the outbreak of the war, and only to a limited extent to increase in cultivation and production.

Hay.—Hay increased from 3,650,419 acres in 1870 to 8,289,407 in 1910. The computed value of the 1919 hay and clover crop is $341,869,200. Canada was able materially to assist the Empire during the War by shipping thousands of tons each year to Great Britain and France. Potatoes, strange to say, though a stable article of diet, have not grown in acreage at all comparably with other field crops. Flax very materially increased, owing to the demand for fibre for aeroplane wings. Corn for ensilage is a valuable crop, especially for dairy cows. In South-West Ontario seed corn matures perfectly, and the growing of corn for seed is now an important industry. The crop of 1919, largely confined to half-a-dozen counties, was valued at $15,860,000. It was thought for a long time that tobacco was a southern crop; but in the United States, Virginia and North Carolina have long since been surpassed, in volume grown, by Wisconsin, one of the cold North-Western States. Ontario and Quebec have been experimenting with the crop for many years, and in the last few seasons have very definitely increased their output. The following table will indicate the start that has been made in Ontario:—

ONTARIO'S TOBACCO INDUSTRY GROWING.

County.	Kind of Tobacco.	Area Acres.	Yield per Acre.	Total Yield.
			lb.	lb.
Essex	Flue-cured	1,450	897	1,300,500
Essex	Burley	3,010	1,200	3,612,200
Essex	Havana, Gold Seal and dark types	800	1,178	942,000
Pelee Island	Burley	700	1,279	895,400
Kent	Burley	2,700	1,189	3,210,500
Kent	Zimmer, Snuff, etc.	265	1,100	291,500
Welland	Burley	8	1,250	9,000
Elgin	Burley	162	1,118	181,200
Prince Edward	Burley	24	1,042	25,000
Lincoln	Connecticut Havana	35	1,037	36,300
Brant	Burley	12	1,400	16,800
Norfolk	Burley	60	1,483	89,000
	Total, 1919	9,226	1,150	10,609,400
	Total, 1918	6,500	1,000	6,500,000
	Total, 1917	2,930	1,192	3,495,000

VALUE OF CANADIAN FIELD CROPS.

In the accompanying table is presented a preliminary estimate by the Dominion Bureau of Statistics of the total value in dollars of the field crops of Canada for the year 1919, as compared with the finally revised estimates of 1916, 1917 and 1918:—

1916.

	Per bush.	Total.
Wheat	1.31	344,096,400
Oats	0.51	210,957,500
Barley	0.82	35,024,000
Rye	1.11	3,196,000
Peas	2.22	4,919,000
Beans	5.40	2,228,000
Buckwheat	1.07	6,375,000
Flax	2.04	16,889,900
Mixed Grains	0.88	9,300,900
Corn for husking	1.07	6,747,000
Potatoes	0.81	50,982,300
Turnips, etc.	0.39	14,329,000

	Per ton.	
Hay and Clover	11.60	168,547,900
Fodder Corn	4.92	9,396,000
Sugar Beets	6.20	440,000
Alfalfa	10.69	3,066,000
Totals	...	886,494,900

1917.

	Per bushel	Total.
Wheat	1.94	453,038,600
Oats	0.69	277,065,300
Barley	1.08	59,654,400
Rye	1.62	6,267,200
Peas	3.54	10,724,100
Beans	7.45	9,493,400
Buckwheat	1.46	10,443,400
Flax	2.65	15,737,000
Mixed Grains	1.16	18,801,750
Corn for husking	1.84	14,307,200
Potatoes	1.01	80,804,400
Turnips, etc.	0.46	29,253,000
	Per ton.	
Hay and Clover	10.33	141,376,700
Fodder Corn	5.14	13,834,900
Sugar Beets	6.75	793,800
Alfalfa	11.59	3,041,300
Totals	...	1,144,636,450

1918.

	Per bush.	Total.
Wheat	2.02	381,677,700
Oats	0.78	331,357,400
Barley	1.00	77,378,670
Rye	1.49	12,728,600
Peas	2.54	7,873,100
Beans	5.41	19,283,900
Buckwheat	1.58	18,018,100
Flax	1.14	40,726,500
Mixed Grains	3.13	18,951,000
Corn for husking	1.75	24,902,800
Potatoes	0.98	102,235,300
Turnips, etc.	0.43	52,252,000
	Per ton.	
Hay and Clover	16.25	241,277,300
Fodder Corn	6.15	29,439,100
Sugar Beets	10.25	1,845,000
Alfalfa	17.84	7,963,500
TOTALS	...	1,367,909,970

1919.

	Per bush.	Total.
Wheat	*1.90	373,086,000
Oats	0.78	320,686,000
Barley	1.15	67,086,000
Rye	1.30	14,304,000
Peas	2.00	7,446,000
Beans	4.90	7,242,000
Buckwheat	1.50	16,967,000
Flax	3.75	25,376,000
Mixed Grains	1.50	39,779,000
Corn for husking	1.25	15,864,000
Potatoes	0.95	124,707,200
Turnips, etc.	0.50	52,365,900
	Per ton.	
Hay and Clover	20.68	341,869,200
Fodder Corn	6.81	32,140,500
Sugar Beets	10.85	2,191,700
Alfalfa	21.61	11,677,400
TOTALS	...	1,452,787,900

*In view of the higher prices now being paid for wheat, this estimate by the Government is below the actual prices obtained.

With the high prices prevailing, the field crops of Canada in 1919 gave a total return of $1,500,000,000.

Live-Stock.—Live-stock is the right arm of agriculture. There is profit in good stock. No one can dispute the fact that high quality live-stock is the surest and safest speciality for the man on the average farm operating over a period of years. Good Canadian live-stock is a big factor in meeting the ever-increasing demand for human food. Soil fertility depends to no small degree upon the plant food returned to the land as farmyard manure. Farm animals turn to profitable account large amounts of feed of a coarse, rough nature that would otherwise waste. They make human food out of roughages, pastures and by-products, and utilise much waste land that cannot be profitably tilled. A large stock gives steady employment to men in winter as well as in summer, and it is generally found that where stock-farming flourishes, agriculture makes progress, and those engaged therein find their work profitable. Self-reliant, trustworthy, satisfied farmers are found where live-stock is kept of the highest quality and in the largest numbers. Canada needs more live-stock farmers and more "high quality" animals. We in Canada are not afraid of the outlay necessary to bring in the best stock. Recently, one of our best Ontario stockmen paid nearly £7,000 in Great Britain for one pure bred animal to place at the head of his herd. We must take off our hats to the live-stock men of Great Britain. They are famous world wide, and we must return

again and again to this country to get new blood in horses, cattle, sheep and swine.

Some of our people, however, at the present time are not taking off their hats to the breeders of Great Britain because they think they are pursuing a very narrowed policy in preventing the descendants of our good imported stock from entering Great Britain to be fed and sold to your citizens in the shape of beef. We have been buying the best here for many years and many of our people cannot understand why the citizens of this country will not allow us to return the progeny of these pure bred beef animals to be finished on your splendid pastures and by your feeders who are recognised to be among the best in the world. That, however, is another question.

Taking the latter period first, it will be seen that the number of horses in Canada has increased from 836,743 in 1871 to 2,598,958 in 1911; cattle have increased from 2,624,290 to 6,526,083, and swine from 1,366,083 to 3,634,778. On the other hand, sheep have decreased from 3,155,509 to 2,174,300. One of the most striking features in this table is the extraordinary increase in the number of horses as between 1901 and 1911. This was undoubtedly due to the opening up of the Prairie Provinces in that decade, and the large influx of immigrant settlers, many of whom came

The following tables give a survey of livestock in Canada from 1871 to 1911.

NUMBERS OF FARM LIVE-STOCK IN CENSUS YEARS 1871-1911.

Description.	1871.	1881.	1891.	1901.	1911.
Horses over 3 years old .	643,171	857,855	1,068,584	1,304,910	1,991,841
Horses under 3 years old –	193,572	201,503	401,988	272,583	607,117
Total Horses	836,743	1,059,358	1,470,572	1,577,493	2,598,958
Milch Cows . .	1,251,209	1,595,800	1,857,112	2,408,677	2,595,255
Other Cattle .	1,373,081	1,919,189	2,263,474	3,167,774	3,930,828
Total Cattle .	2,624,290	3,514,989	4,120,586	5,576,451	6,526,083
Sheep . . .	3,155,509	3,048,678	2,563,781	2,510,239	2,174,300
Swine . . .	1,366,083	1,207,619	1,733,850	2,353,828	3,634,778

INCREASE IN NUMBERS OF FARM LIVE-STOCK, 1871-1911.

Description	1871-1881.		1881-1891.		1891-1901.		1901-1911.	
	No.	Per cent	No.	Per cent.	No.	Per cent.	No.	Per cent.
Horses . . .	222,615	27	411,214	38	106,921	7	1,021,465	65
Milch Cows . .	344,591	28	261,312	16	551,565	30	186,578	8
Other Cattle .	546,108	40	344,285	18	904,300	40	763,054	24
Total Cattle .	890,699	34	605,597	17	1,455,865	35	949,632	17
Sheep . . .	*106,831	*4	*484,897	*19	*53,542	*2	*335,939	*13
Swine . . .	*158,464	*14	526,231	43	619,978	36	1,280,950	54

Description.	1871-1911	
	No.	Per Cent.
Horses	1,762,215	211
Milch Cows . .	1,344,046	107
Other Cattle . .	2,557,747	186
Total Cattle . .	3,901,793	149
Sheep	*981,209	*45
Swine	2,268,635	166

NOTE.—The sign (*) indicates a decrease.

from the United States, bringing their horses and cattle with them. This is shown by the following table, which gives the number of horses in Canada by Provinces with the absolute and percentage increase for each Province. The second table shows the numbers of farm live-stock per 1,000 of the population, and this table, in which the figures are those of the census, affords, perhaps, the best measure of the progress of Canada in growth of live-stock.

NUMBER OF HORSES, ALL AGES, BY PROVINCES, 1901 AND 1911.

Provinces.	Horses of all Ages.		Increase (+) or Decrease (—)	
	1901	1911	Total	Per cent.
Canada	1,577,493	2,598,958	+1,021,465	+64.75
Prince Edward Island	33,731	35,935	+2,204	+6.53
Nova Scotia	62,508	61,420	—1,088	—1.74
New Brunswick	61,789	65,409	+3,620	+5.86
Quebec	320,673	371,571	+50,898	+15.87
Ontario	721,138	812,214	+91,076	+12.63
Manitoba	163,867	280,374	+116,507	+71.10
Saskatechewan	83,801	507,468	+423,667	+505.56
Alberta	92,661	407,153	+314,492	+339.40
British Columbia	37,325	57,414	+20,089	+53.82

NUMBERS OF FARM LIVE-STOCK PER 1,000 OF THE POPULATION, 1871-1911.

Year	Population.	Horses.	Milch Cows.	Other Cattle.	Total Cattle.	Sheep.	Swine.
1871	3,689,257	221	339	372	711	855	354
1881	4,324,810	245	369	443	813	729	279
1891	4,833,239	304	384	468	852	534	358
1901	5,371,315	293	448	590	1,038	467	428
1911	7,206,643	360	360	545	905	302	504

For horses and cattle it will be noted that the numbers per 1,000 of the population have steadily increased from 1871 to 1901, whilst in the case of sheep they have as steadily declined. In the numbers of swine there is a greater fluctuation. This agrees with the known conditions of the swine-feeding industry, which depends largely upon the supplies of low-priced feeding grains. During the forty years the number of swine per 1,000 of the population increased from 354 to 504.

In the ten years 1901 to 1911 there was a falling off in the number of cattle per 1,000 of the population. This is explained by the movement of population during the first decade of the century. Generally the urban population increased in a ratio far in excess of the rural. The marked decrease in the number of sheep, is an unsatisfactory feature of Canadian farm live-stock statistics during the last fifty years. Various causes account for this decrease, amongst these being the low price of meat and wool.

Continuous annual estimates of the numbers of farm animals in Canada from 1907 to 1917 are given in the following Table :—

ANNUAL ESTIMATE OF THE NUMBERS OF FARM ANIMALS, 1907 TO 1917.

Year	Horses.	Milch Cows.	Other Cattle.	Total Cattle.	Sheep.	Swine.
1907	1,923,090	2,737,462	4,394,354	7,131,816	2,783,219	3,445,282
1908	2,118,165	2,917,746	4,629,836	7,547,582	2,831,404	3,369,858
1909	2,132,489	2,849,306	4,384,779	7,234,085	2,705,390	2,912,509
1910	2,213,199	2,853,951	4,260,963	7,114,914	2,598,470	2,753,964
1911	2,598,958	2,595,255	3,930,828	6,526,083	2,174,300	3,634,778
1912	2,692,357	2,604,488	3,827,373	6,431,861	2,082,381	3,477,310
1913	2,866,008	2,740,434	3,915,687	6,656,121	2,128,531	3,448,326
1914	2,947,738	2,673,286	3,363,531	6,036,817	2,058,045	3,434,261
1915	2,996,099	2,666,846	3,399,155	6,066,001	2,038,662	3,111,900
1916	3,258,342	2,833,433	3,760,718	6,594,151	2,022,941	4,474,840
1917	3,412,749	3,202,283	4,718,657	7,920,940	2,369,358	3,619,382

Statistics to show the value of farm live-stock were not collected until 1901. The following Table shows the values for each description for the two years 1901 and 1911, according to the Census, and for each of the years 1913 to 1917, as estimated by the Census and Statistics Office.

VALUES OF FARM LIVE-STOCK IN CANADA, 1901 AND 1911 AND 1913—1917.

Year	Horses.	Milch Cows.	Other Horned Cattle.	Total Cattle.	Sheep.	Swine.	Total.
	000 $	000 $	000 $	000 $	000 $	000 $	000 $
1901	118,279	69,238	54,197	123,435	10,491	16,446	268,651
1911	379,315	108,605	86,697	195,302	10,826	27,607	613,050
1913	420,079	115,369	86,522	201,891	10,673	26,665	659,308
1914	371,430	153,633	143,498	297,131	14,551	42,418	725,530
1915	373,381	163,919	152,461	316,380	16,227	43,653	749,640
1916	418,686	198,896	204,477	403,373	20,927	60,700	903,686
1917	429,123	274,081	270,595	544,676	35,576	92,886	1,102,261

The Table shows that the total value of farm live-stock in Canada, including horses, cattle, sheep and swine, has increased from $268,651,000 in 1901 to $1,102,261,000 in 1917. This, of course, is due not so much to increase of numbers as to the rise in the prices of food animals since 1914, due to the war. The numbers of farm animals in Canada have increased since 1901 by 1,835,256 horses, 2,344,489 cattle, and 1,265,554 swine, whilst sheep have decreased by 140,881. Since 1913 the average values per head are for all animals, except horses (which are less) between two and three times more than they were in 1913.

Canada is essentially a live-stock country. It is not only profitable year in and year out, but it keeps the farms up to a high standard of production. Just now Belgium and France and Germany are in the market for fat cattle, and Great Britain can obtain only one-tenth of the Canadian goods, such as beef, bacon, eggs, etc., that she requires. There is a steady increase from Canadian stock-yard returns, and on all hands Canadian farmers are being advised to increase their live-stock holdings.

Poultry.—The poultry business has assumed large proportions in Canadian agriculture in recent years, and while there are many persons who raise poultry in towns and cities and villages, it is really a farmer's business in the aggregate. As a matter of fact, there are few men or women in Canada who make much money, or even a good living by poultry husbandry alone. The farmer has a larger range for his flock, ensuring good health; his fowls find a great deal of their food in the fields and barn-yards and stables. He has cheap feed from his threshings of grain, and his children or womenfolk supply most of the labour. On the other hand, the townsman has none of these conditions, and at the present time it costs 30 cents. per month to feed a well-grown chicken or full-grown hen. This alone makes it almost impossible to raise poultry profitably where all the feed has to be purchased.

The poultry industry is attracting the attention of returned soldiers, especially those rendered unfit for the heavier kinds of farming. These men are being assisted by the Government to obtain small farms, where, in addition to raising fowls and eggs for market, they may grow most of the feed, and besides keep a cow and grow their own vegetables.

The Census reports show the number of fowl to be as follows:—

	Turkeys.	Geese.	Ducks.	Hens and Chickens.
	No.	No.	No.	No.
1911	863,182	629,524	527,098	29,773,457
1901	584,569	395,997	290,755	16,651,337

DAIRYING.

Perhaps the "dairy cow" has done more for Canadian agriculture than any other agency. Butter takes nothing from the soil, and the manure from dairy stables greatly enriches the land. Therefore, wherever dairy-farming is practised, the land actually increases in productive value from year to year. In the

aggregate, also, milk products constitute a very large part of our export business.

The establishment in Canada of the dairying industry upon a factory basis has been one of the most significant agricultural developments since Confederation. The production of grain in the Prairie Provinces, which began to assume importance with the completion of the Canadian Pacific Railway in 1886, and the effect of the McKinley Tariff of 1890, rendered grain-growing in Eastern Canada unprofitable; and the farming situation was only saved by the increased production of dairy products, for which a market was gradually built up with the United Kingdom. The first cheese factory on the western side of the Atlantic was started in Herkimer County, in New York State. Five cheese factories started in Ontario between the years 1855 and 1860, but between 1861 and 1870 eighty-three dairy factories were started in Canada, of which one factory made butter only, fifty-seven factories made cheese only, and twenty-five made both butter and cheese.

The introduction into Canada from Denmark in 1882 of the centrifugal cream separator marked an important epoch in Canadian dairying. From that time the industry has continued to expand. As shown in the following *Table, statistics of home-made butter have been collected by the decennial census since 1870, as also of home-made cheese, excepting in 1900.

Statistics of the factory production of butter and cheese have formed part of the census of manufactures; but they have been limited to the number of employees and to the value of capital, salaries, wages, raw materials and products; they have not distinguished separately between butter and cheese. The total value of the products of butter, cheese and condensed milk factories was $37,232,969 in 1910, as compared with $29,731,922 in 1901, and $10,780,379 in 1891, the year of first record. The first attempt to collect comprehensive statistics of the dairying industry was made in connection with the decennial Census of 1901. This was followed in 1907 by a postal Census of dairying, and in 1911 by the decennial Census of that year. In 1917 the Dominion Bureau of Statistics, in co-operation with the Provincial Governments, began an annual inquiry into the production of creameries and cheese factories, the results of the first year's inquiry embracing the years 1915 and 1916. In 1918, the dairying statistics of 1917 were collected as part of a general census of industry. ‡The following Table, combining all the records available, shows the production and value of creamery butter and factory cheese for each of the years 1900, 1907, 1910, 1915, 1916 and 1917.

*Production of Home-Made Butter and Cheese in the Census Years 1870, 1880, 1890, 1900 and 1910.

Description.	1870.	1880	1890.	1900.	1910.
	lb.	lb.	lb.	lb.	lb.
Butter . .	74,190,584	102,545,169	111,577,210	105,343,076	138,098,534
Cheese . .	4,984,843	3,184,996	6,267,203	...	1,363,261

"Values" were not collected until 1910, when the value of home-made butter was $30,280,608, and of home-made cheese $153,036.

‡Production and Value of Creamery Butter and Factory Cheese, 1900, 1907, 1910 and 1915-7.

Year	Source.	Establishments.	Creamery Butter.		Factory Cheese.	
			lbs.	$	lbs.	$
1900	Decennial Census	3,576	36,066,739	7,240,972	220,833,269	22,221,430
1907	Postal Census	3,515	45,930,294	10,949,062	204,788,583	23,597,639
1910	Decennial Census	3,625	64,698,165	15,645,845	199,904,205	21,587,124
1915	Census and Statistics Office	3,513	83,991,453	24,385,052	183,887,837	27,097,177
1916	Census and Statistics Office	3,446	82,564,130	26,966,357	192,968,597	35,512,622
1917	Dominion Bureau of Statistics	3,418	87,404,366	34,227,188	194,904,336	41,170,563

The figures in the foregoing Table relate solely to the production of creamery butter and factory cheese; they do not include butter made on the farm, and known as "dairy butter," which constitutes the larger proportion of the total production; nor do they include the small proportion of home-made cheese. By adding together the quantities and values of the creamery and home-made butter, we get a total butter production in Canada for 1910 of 202,796,699 lbs. of the value of $45,926,553, as compared with 141,409,815 lbs. in 1900. Of cheese, the total production in 1910 was 201,267,466 lbs., of the value of $15,798,881. No continuous annual statistics of the dairying industry being available before 1915, we must rely for further evidence of the progress of the industry upon the export returns of butter and cheese.

million pounds in the five years ended 1912, and 3.2 million pounds for the five years ended 1917. Of cheese, the exports rose continuously until the five years ended 1907, when they reached the maximum, viz., 214,558,000 lb. From this date they declined to 176,165,000 lb. and 157,398,000 lb.; the averages for the five years ended, respectively, 1912 and 1917. The demands created by the War, and the consequent high prices, caused a decided increase in the exports of both butter and cheese, these amounting for butter to 3,441,183 lb. in 1916, and 7,990,435 lb. in 1917, and for cheese to 168,961,583 lb. in 1916, and 180,733,426 lb. in 1917.

It has sometimes been too hastily assumed that the falling-off in the exports of butter and cheese, as shown in the above table represents a decline in the Canadian dairying

EXPORTS OF CANADIAN BUTTER AND CHEESE TO THE UNITED KINGDOM, TO THE UNITED STATES, AND TO OTHER COUNTRIES IN QUINQUENNIAL AVERAGES, 1868-1917.

Period.	United Kingdom.	United States.	Other Countries.	Total.	United Kingdom.	United States.	Other Countries.	Total.
	000 lbs.	000 lb.	000 lb.	000 lbs.	000 $	000 $	000 $	000 $
BUTTER.								
1868–1872	9,717	4,249	1,130	15,097	1,732	823	204	2,760
1873–1877	9,493	1,999	1,238	12,730	1,993	444	238	2,676
1878–1882	13,568	926	1,237	15,732	2,445	177	190	2,810
1883–1887	5,354	304	1,074	6,733	1,070	61	181	1,312
1888–1892	2,534	47	949	3,530	457	8	159	625
1893–1897	5,779	31	902	6,712	1,079	5	161	1,246
1898–1902	19,269	69	829	20,168	3,798	12	155	3,965
1903–1907	25,064	118	1,331	26,514	5,426	25	288	5,739
1908–1912	4,190	498	851	5,543	971	90	223	1,284
1913–1917	1,959	526	757	3,242	600	111	225	936
CHEESE.								
1869–1872	6,926	48	31	7,005	825	6	4	835
1873–1877	27,980	1,285	101	29,366	3,265	160	13	3,438
1878–1882	43,782	1,102	95	44,979	4,421	107	10	4,538
1883–1887	71,372	312	150	71,834	7,118	33	15	7,166
1888–1892	97,823	327	138	98,288	9,626	35	14	9,675
1893–1897	152,439	71	257	162,767	14,318	10	27	14,356
1898–1902	193,325	157	395	193,877	18,856	17	44	18,917
1903–1907	213,751	72	735	214,558	23,021	10	96	23,127
1908–1912	175,181	180	804	176,165	21,165	26	111	21,302
1913–1917	155,782	411	1,205	157,398	24,166	63	209	24,438

NOTE.—In 1868 the exports of cheese were included with those of butter.

It will be seen that both for butter and cheese the bulk of the trade is with the United Kingdom. Between 1883 and 1897 there was a considerable falling off in the exports of butter; but between 1898 and 1907 they reached their highest point, declining, however, to averages of only 5½

industry, but dairying experts are well aware that this is not the case; for, owing to the increase of immigration, and especially the settlement of immigrants in urban centres, the milk flow has been merely diverted into different channels. Cheese for export has been replaced by the

manufacture of butter sold for home consumption, and there has been a large demand for milk for the growing towns and cities.

Fruit-Growing.

There is something alluring about fruit-growing. Townspeople who wish to try their hand at farming select an orchard or garden for their operations. Cultivation and caring for trees appeals to men and women who wish to live and work in the country, but have no special love for live-stock. There is found, therefore, in Canada, in the specially favoured fruit-growing districts, such a desire to own and operate farms that the land has increased greatly in value. One thousand dollars an acre is not an uncommon price for orchard ground in the Niagara Peninsula. Fruit-growing and vegetable-growing or "truck-farming," as it is usually called, are not as safe or sure in their financial returns as general farming. The man on the ordinary farm grows the feed for his horses and other live-stock, and produces most of the food required for his family. He has also a variety of crops, and so strikes an average of production, no matter whether the season be dry or wet. He has, too, something to sell every month in the year, and so is assured of at least a good living.

The purely fruit farmer, on the other hand may have his blossom buds killed in the winter and lose the next season's crop. The crop is perishable, and he frequently experiences an extremely hot spell, maturing the fruit so suddenly that much of it may spoil before he can get it to market. A favourable season means that the whole district has a good crop and prices go down accordingly. With peaches, especially, there are off seasons when whole orchards do not produce a basket of fruit. The canning factories, which are now found in nearly every fruit section, make a valuable market for growers. Fruit need not be so carefully packed, and it is not long in transit. It may be delivered any hour of the day or in busy seasons at night. It need not be graded as to size, for even fruit of inferior quality or size may be profitably sent to the factory to be made into preserves or jam or cider.

Fruit-growing in Canada has also the disadvantage of not giving work for hired help in the winter season, and, again, of requiring much help in busy seasons. It is, however, an attractive occupation, and the best fruit farmers are prosperous. They spray their trees with poison solutions for insects and fungus diseases, fertilise and cultivate thoroughly, prune their trees properly, and pick and pack well. They also watch the markets, and by co-operation in selling usually avoid a glutted market.

Some Fruit Statistics.

The following table shows the number of orchard trees in Canada in 1901 and 1911, and the production of fruit:—

Kinds.	Trees Bearing.		Trees Non-Bearing.	
	1901.	1911.	1901.	1911.
	No.	No.	No.	No.
Apples	11,025,789	10,617,372	4,028,086	5,599,804
Peaches	819,985	839,288	481,790	1,056,359
Pears	617,293	581,704	344,808	385,538
Plums	1,453,269	1,075,130	963,426	637,220
Cherries	903,140	741,992	385,228	495,082
Other	141,870	146,659	37,555	141,233

Kinds.	Production of Fruit.		
	1890.	1900.	1910.
	Bush.	Bush.	Bush.
Apples	7,563,894	18,626,186	10,618,666
Peaches	43,690	545,415	646,826
Pears	229,283	531,837	504,171
Plums	269,631	557,875	508,994
Cherries	197,090	336,751	238,974
Other	324,789	70,396	47,789

The next Table gives the value of fruits and vegetables separately in 1910, and compares the totals for 1910 and 1900, adding the percentage of increase in ten years :—

Provinces.	Value in 1910 of— Orchard Fruits.	Small Fruits.	Vegetables.
	$	$	$
Canada	9,728,533	3,052,592	18,806,544
British Columbia	1,022,576	312,528	1,023,263
Alberta	401	6,469	1,129,922
Saskatchewan	327	3,828	1,047,082
Manitoba	7,146	14,690	1,428,402
Ontario	5,564,133	2,254,913	6,043,617
Quebec	1,186,479	284,633	5,797,666
New Brunswick	267,993	62,806	873,861
Nova Scotia	1,547,245	87,161	1,392,039
Prince Edward Island	132,233	25,564	70,692

Provinces.	Value of Fruits and Vegetables in— 1910.	1900.	Increase per cent. in 10 years.
	$	$	Per cent.
Canada	31,587,669	12,994,900	143.08
British Columbia	2,358,367	435,793	441.17
Alberta	1,136,792	32,079	3,443.73
Saskatchewan	1,051,237	48,474	2,068.66
Manitoba	1,450,238	163,958	784.52
Ontario	13,862,663	7,809,084	77.52
Quebec	7,268,778	2,564,801	183.41
New Brunswick	1,204,660	394,337	205.49
Nova Scotia	3,026,445	1,407,369	115.04
Prince Edward Island	228,489	139,004	64.38

For all Canada the aggregate value of all fruits and vegetables in 1910 was $31,587,669 :—

Orchard fruits $9,728,533
Small fruits.......... $3,052,592
Vegetables $18,806,544

EXPORTS AND IMPORTS OF FRUIT.

Year.	Exports.	Imports.
	$	$
1891	1,487,336	261,382
1901	1,633,604	337,674
1911	1,975,987	1,531,077

From 1891 to 1901 the value of exports increased by 9.83 per cent., and of imports by 29.18 per cent., while from 1901 to 1911, exports increased by 20.95 per cent. and imports by 353.42 per cent. Of the total value of all fruits exported, apples obtained 93.43 per cent. in 1891, 90.77 per cent. in 1901, and 88.91 per cent, in 1911. The value of apples imported in 1891 represented 21.08 per cent. of the total value of all fruits imported, as compared with 21.97 per cent. in 1901 and 31.84 per cent. in 1911.

The average production of apples per head of the population two years of age and over in 1891 was 1.68 bushels, as compared with 3.73 bushels in 1901, and 1.59 bushels in 1911. If to the quantity retained for home consumption in each decade be added the quantity of apples imported, we find that the average consumption for the population two years of age and over at each Census period was 1.39, 3.34 and 1.42 bushels respectively.

In a country so richly endowed by climate and soil for growing fruit and vegetables, one is frequently asked why Canada imports so many products of the orchard, vineyard and garden. Truth compels one to state

that there is no earthly reason why northern-grown fruit should be imported. It must be kept in mind, however, that most of the orchards of Canada are located on general farms, where the farmer has to care for his orchard in what little time he can spare from his field crop and live-stock operations. His apples and pears and plums are usually neglected and inferior quality results. Again, people living in cities and towns demand fruit out of season. Strawberries in the winter time, then other small fruits, then peaches, cherries, plums and pears come on the market from the Southern States months before the Canadian crop is ripe. Add to that tropical fruits, such as pineapples, oranges, bananas, raisins and currants, and the importations run into millions of dollars.

The various farming activities show a percentage revenue as follows :—Field crops, 70 per cent.; dairy produce, 14 per cent.; animals, 10 per cent.; fruit, vegetables, poultry, eggs and wool 6 per cent.

AGRICULTURAL EDUCATION.

In 1866 there was but one Agricultural School in Canada, which was located at St. Anne de la Pocatiere, in the County of Kamouraska, Que. Founded seven years before Confederation, it is still active and prosperous. When Ontario became a Province in 1867, the only farmers' organisation of any kind was the Agricultural Society. A Provincial Board of Agriculture and Arts controlled this organisation, and through it gave a course of instruction at the University of Toronto. The new Provincial Government decided that special provision must be made for training students in farming and the Mechanics' Arts. Out of this resolution came the School of Agriculture at Guelph and the School of Practical Science at Toronto. A progressive Minister of Education also introduced agriculture into the public schools. It may be said that in 1870 the first serious attempt was made to inaugurate a system of agricultural instruction in Canada.

The school at Guelph made progress from the beginning. Two special courses of study and experiment were inaugurated. The students were taught the sciences underlying the practice of agriculture, and on the farm of 500 acres attached to the college, experiments were conducted with a view of ascertaining the best methods of handling the soil, feeding and breeding live-stock, developing orchards, growing crops, and handling bees and poultry. For a long time, however, the farmers of Ontario doubted the value of what they called "book learning." But as the practical application of college teaching became understood, and as the students returned to actual farming, the school justified itself, and in 1919 there were more than 2,000 sons of farmers in attendance.

By experimental work on the college farm, new varieties of plants have been developed and distributed to the 5,000 members of the Experimental Union on the farms of Ontario. The result has been that O.A.C. varieties of wheat and oats and barley are now the staple crops of the Province, and are grown by hundred of thousands of bushels. The college has now a graduate officially appointed by the Government to supervise agriculture in each county. These men take the college teaching to every farmer in their districts. As new Provinces were formed and grew in population, new Colleges of Agriculture have been provided, until there now exists a chain of such institutions from the Atlantic to the Pacific, and under their auspices fully 5,000 men and women are receiving instruction each year. The spread of weeds, injurious insects, fungus diseases, diseases of animals, the introduction of gasoline as a factor in farm power, multiplication of new machinery, new methods of handling milk, poultry and bees, and other changing conditions require every farmer's son to have a course of instruction in his father's business. The Colleges of Agriculture, therefore, have fulfilled a very important function in Canada, and such a number of students are now applying at these institutions that many must be refused, unless an immediate increase in accommodation is provided. With millions of acres of land ready to be tilled, with prices high for all farm products, and with a climate and soil to attract immigrants, the next few years should witness a great expansion of agriculture in Canada.

DISCUSSION.

THE CHAIRMAN (Sir Daniel Hall, K.C.B., F.R.S.), in opening the discussion, said that perhaps the most significant figure contained in the paper was that in 1915 Canada managed to produce 393,000,000 bushels of wheat, which was a vital factor in the prosecution of the

war on the part of the Allies. At the time the resources not only of the United Kingdom but of the Empire and all the Allied peoples were beginning to run short, and if Canada and the United States had not been able to make an unexampled expansion in their output of wheat the Allies might very well have been driven to a standstill before the actual termination of the war. He did not think it was possible to exaggerate the good fortune that thus befell the Allies by reason of the bountiful harvest in Canada and the United States in 1915, whereby the reserves of wheat were built up. He wished he could share the author's optimism in connection with the removal of all danger of starvation or even of serious scarcity of famine to the world at the present time. The author's remarks were, he thought, too optimistic in view of the widespread conditions of famine and scarcity of food which were prevailing over a very large portion of Europe. In his opinion it would be many years before the menace of starvation was removed from what used to be considered the most civilised countries of the world. The prices of wheat had dropped tremendously during the present year, and the people of this country thought they were in a comparatively fortunate position, but that had been due to a large extent to a very singular combination of circumstances which could not be counted on year after year, namely, that in the last cereal year there was a very considerable carry-over into the present cereal year, both from Canada and from the United States; the Argentine yielded well and there was an exportable surplus of live-stock from Australia and of live-stock and cereals from India. Those circumstances would not occur quite in the same order year after year, and in addition the world had to a very large extent grown up to the maximum of population which it was possible to supply with the present stores of food. That process was very palpably going on before the war, when the United States had almost ceased to be an exporting country so far as many important foods were concerned. Her population had grown up to her own production, and now as a result of the war a very large proportion of the old population of the world that took to agriculture had been put out of action and had gone away from its pursuit. He had had opportunities of discussing the matter with the representatives of other European countries, and there could be no doubt that the war had definitely driven men away from agriculture. The curious tendency existed that once men were drawn away from the land they did not go back to it; and all over the world, as a consequence of the upset caused by the war, high wages and the lure of the city, men had been drawn away from agriculture and had not gone back again. Nor would they go back even under pressure. The growth of the agricultural population would only occur as fresh workers were born on to the soil. The great danger this country ran was that, owing to the diminishing output of the old world and even of some of the new countries, its supplies were no longer in excess of its demands, as they were for twenty or thirty years before the war, but were in imminent danger of running short. The population would always grow up to its food supply, and although the danger was minimised by the improvements in facilities of transport which equalised the crop failures in different parts of the world he did not consider that the world was yet free from the risk of famine. The author had pointed out that in Canada, in addition to the immense increase which had occurred in the area devoted to crops, the output per acre had also been increased. That improvement in output was the great hope for the future in supplying the steadily increasing population. Despite the very large acreage available in Canada it was certain that the same expansion of area of land devoted to the production of food was not available to the agriculturist at the present time as was the case forty or fifty years ago. From 1875 onwards a great opening up was seen in the United States, in the middle west, the Canadian northwest, Argentina, and great parts of Australia whereby a superabundance of the staple articles of food, such as wheat, was produced for European countries. That sort of expansion could not occur again, because the land no longer existed. It would only occur again when Russia and Siberia once more became available for general agricultural cultivation and for export. For the time being, however, the world had reached its limits of size as it were, and to get increased production it was necessary to obtain increased yield per acre. Two methods were available for that purpose. First of all, there was the use of machinery, in connection with which Canada provided the greatest object-lesson to the English agriculturist. The author had alluded to the superiority of British farmers in the fine artist's work of the raising of live-stock. Personally he thought that even in regard to the cultivation of the soil there were no farmers who could match the best British farmers, say, in the East Lothians and on the great potato lands of Lincolnshire, where the most beautiful agriculture and the most skilled management in the world existed. None the less it would be of the greatest possible benefit that some of our younger farmers should be sent across to Canada and Australia with the object of studying the agricultural methods adopted there. They would there learn a new ideal—not merely how to get the most out of the land but how to get the most out of the man. In view of the great rise in wages which had occurred in this country it was necessary for farmers to learn how, by the aid of machinery, to make the very most out of the men that were employed upon the land. The other line of attack which would help in that particular direction was research and the education which

brought that research home to the mind of the individual farmer. It was impossible to exaggerate the benefits that were still latent in research. Taking one particular line only, the introduction of new varieties of wheat by deliberate scientific breeding upon Mendelian principles or pure line selection had already increased by 10 or 20 per cent. the output of individual farmers in this country and Canada. He had not the figures at his disposal, but he believed the introduction of Marquis wheat alone had been responsible for a very large amount of the increase in the output of wheat in Canada, because it meant that very large areas of country on which wheat could not be grown before could now be put under that rapidly-ripening wheat which was harvestable before the autumn frosts came along. The author had alluded to the part Great Britain had played in the breeding of live-stock, which after all was the prerogative of an old settled country and of a traditional agriculture. It was due to men who looked at their business not simply from the strictly business point of view but to a certain extent from the artist's point of view. A great many of the prominent men connected with the breeding of live-stock in this country were not making money out of it; they were simply farming that section of their business for the pride they had in their animals. It was hardly to be expected that in a new country, where there was the immediate necessity of obtaining returns and where things were being done on a very large scale, farmers should attain to that personal feeling that characterised the old traditional stock farmers in this country. The author had trailed his coat over one very debatable question, namely, the introduction of live-stock into this country. He desired to point out that there was no discrimination in this country, as was sometimes represented, against Canada, but because England had always had an enormous pride in its live-stock and because it was an island it had always taken advantage of the ring that was naturally drawn round it to say that no live-stock should come across that ring, which was the best barrier against disease being imported into the country. It was not a question of discrimination against Canada or any other country; it was a general measure for the protection of what the author agreed was one of the greatest prides and possessions of British agriculture. The author had alluded to the growth of education and how susceptible to education the Canadian farmer was. For a long time the author and his colleagues had had a great advantage over the corresponding people on this side, in view of the fact that Canadian farmers were more susceptible to the teaching of Agricultural Colleges and took more kindly to the professor. The reason for that was that many Canadian farmers were not traditional farmers; they were not born into their routine and into the belief that they were the possessors of the true light and that all teachers must be outsiders and intruders. He was glad to say the situation was changing in this country, and he hoped before long farmers in England would have just the same belief in education and research as was apparent in Canada.

Mr. Percy Hurd, M.P., said there was upon the platform a most suggestive combination in the person of the author, who had been the head of the foremost Canadian agricultural college, and the Chairman, who was one of the acknowledged masters in the application of science to the art of agriculture. That suggestive combination had a very direct bearing upon the problem the Chairman had dealt with, namely, the population overtaking the production of the world. In the combination to which he had referred a suggestion might be found for future action, because the problem was really an Empire one. Conferences were at the present time taking place between the representatives of the British and Overseas Governments with a view to facing the population problem from an Empire point of view, and the question of the production of the Empire should be faced in a similar co-operative spirit. During the past autumn he had the advantage of touring through Canada, and the possibility of the mutual advantages of co-operation was brought home to him everywhere he went. There was in this country a vast store of tradition in agricultural production. This country touched the top notch in all lines of production in agriculture. It was not a question of this country not producing the best, but it did not produce enough of it. That British tradition must be of enormous value to a new country like Canada, which possessed initiative and freedom from prejudice. No one could fail, when in Canada, to be impressed with the way in which machinery was absolutely revolutionising Canadian farming, but the telephone was doing almost as much as the motor and machinery. Most of the farmers were in instant touch, by means of the telephone, with the elevators and with the markets for their produce. He hoped Mr. Illingworth, the Postmaster-General, would see the wisdom of sending a representative to Canada and the United States with the object of finding out what the telephone was doing there for the farmer, because he was sure an extension of the rural telephone system of the country would be of immense advantage to the farming community. Think also what hydro-electric power was doing to change the face of agriculture in Ontario. There was no Niagara in this country, but there was a Severn, and it was to be hoped that engineers would evolve means whereby hydro-electric power could be produced for the benefit of the British farmer. Sixty per cent. of the great asset of the country, coal, was now wasted in poisoning the air,

The time was coming in England, under the new competitive conditions of the modern world, when it would be necessary to conserve the power that was now wasted and use it for the regeneration of agriculture and industry. By such means a solution of our present problems would be obtained in this country far better than that obtainable by any other race in the world.

Prof. H. E. Armstrong, F.R.S., said that having seen a good deal of Canada he desired to congratulate the author on the wonderful progress that had been made in agricultural education in that country, where there was a substantial chain of colleges extending from east to west. They compared most favourably with those in this country, in which he did not think there was a single satisfactory going concern; at any rate, in comparison with Canada ours did not touch the farmer in the way that the Canadian institutions did. It must be confessed, however, that the conditions in Canada were very different from those that existed in this country. The Canadians possessed receptive minds, whereas it was very difficult to deal with agriculturists in this country. In the instructive table the author had given of yields of cereals in different parts of the world he had forgotten to include the biggest figure of all, namely, Denmark, 45, which was a very astounding result and headed the world. Personally he felt that great hopes ought not to be held out of increasing crops with the object of increasing populations. His own serious view was that the world had reached its summit in that respect, and that if possible it should diminish and not increase its population. The author had stated that five-sixths of the Canadian soil was uncultivated at the present time, but personally he ventured to think it was not to the interest of Canada or of the world that that soil should be too rapidly occupied. It would be of interest if the author could state at what rate that part of the land which was in occupation was being used up, because it would then be possible to estimate how long it would take to use up the remaining five-sixths. He would also like to ask what was going to happen when that area was exhausted. Would it then be possible to farm out in the far west of Canada? At the present moment all the farmers did was to scratch the soil, sow the seed and collect the harvest, but they did not farm in the English sense of the term. He would like to know whether the conditions were such that it would be possible to introduce farming in the proper sense of the term, by introducing a system of rotation, so as to maintain the fertility of the soil. The Chairman referred to the importance of increase of yield, which meant not only cultivation but the use of fertilisers. Were those fertilisers going to be available, more particularly phosphates? His own feeling was that the limiting food factor was phosphates. There had been a good deal of talk in the papers about the neglect of Australia. He had been thinking out a letter headed: "What is the size of Australia from the point of view of cultivable soil?" He thought the Chairman would agree with him in the statement that when they were in Australia in 1914 one of the things which struck them more than anything else was the extraordinary infertility of a great deal of the soil, and the marvellous way in which it responded to small doses of phosphate, because there was no phosphate in the soil. In order to make a large area of Australia available for the growth of food it would be necessary to supply artificial fertilisers, even supposing water could be obtained, which was another difficulty. Reference had been made not only in the paper, but in the course of the discussion, to chemists. He appealed to his hearers not to put their faith in such chemists, whatever they did, in connection with food values. At the beginning of the War a Food Committee was appointed by the Royal Society which misled the country for years. It told the people that they must feed themselves on the basis of the amount of energy in the food. No falser doctrine was ever preached. He and one or two others protested against it, but it was not until the War was nearly at an end that these learned people began to see that the protests that had been raised against their "scientific" system of feeding were justified. Everything that had happened since went to show that it was impossible to deal with food from that point of view. The more common sense, the less half science were put into ordinary average food, the better it would be. The author had made out a list of foods in which he had given oats a value of 100 and wheat 92, while milk was nowhere. There was not a single food which was worth taking by itself except milk, which the author had put last on the list. It was the only food by itself on which people could live; they could not live on any others alone. It was necessary to mix the diet. With regard to the author's reference to turnips, it was well recognised that the same principle applied to cattle as to human beings, and that cattle would produce a milk that was worth drinking if they were fed on turnips and swedes but not if they were fed on mangolds. If the people of this country were to farm with advantage in order to produce food which was good food it would be necessary to pay far more attention to that subject than had been the case in the past. It would be necessary not merely to consider crop yields but what was of great importance, crop quality, an almost untouched field of investigation. No greater calamity had happened to the infantile population of this country than the shortage of butter, milk and eggs. That vitally affected the whole question of the growth of the population. It was impossible to have a sound population unless a

mixed diet of the proper character were used. Only quite recently a very interesting set of results had been brought forward which solved a question in which he had long been interested. It was observed at an early date that lard was a fat of inferior value, since some of the food constituents to which the author had referred were missing from it. The pig was therefore put down as producing a fat that was only of value as a fuel. It had recently been established that if pigs were fed on grass as well as on artificial food, they produced a wholesome and efficient fat, just the same as other animals.

DR. J. A. VOELCKER, in alluding to the excellent work that had been done by the Guelph College, particularly emphasised the part played by Dr. William Sanders and Mr. F. T. Shutt in the work of agricultural enquiry. He received regularly, and was much interested in reading, the reports of the different Experimental Stations in Canada. The Dominion Bureau of Statistics issued monthly statements in regard to the agricultural position which were of great value, and he noted with pleasure that one of those chiefly responsible for the work was Mr. E. H. Godfrey, who was formerly connected with the Royal Agricultural Society of England. Canada possessed particular advantages in that its people took more kindly to the teaching of agricultural science than did the farmers of this country, and a tribute should be paid to the author for all he had done in forwarding that good work. The author had pointed out that Canada had to come to the old country for its cattle from which to breed, but the people of this country in their turn had to go to Canada, not only for their food supplies, but also for the seed with which to improve the quality of their corn. The work which Prof. Biffen had done in crossing the Canadain red Fyfe wheat, in order to obtain a wheat which would combine the milling qualities of the red Fyfe with the heavy yield of the English varieties, was well known throughout the country, and much good work had been done also by Dr. Sanders and others in perpetuating the new breeds of wheat. The British agriculturist was old-fashioned in some ways and did not take kindly to teaching, but, along with that, he possessed a sort of innate knowledge of the soil and the surroundings of agriculture which was peculiar to this country. That innate knowledge had come from long experience, and it was not confined to agriculture by any means. In our English industries, whether it was iron-smelting or glass-making or anything else, there were always to be found practical men, who knew better than anybody else the exact point at which to stop a process or to introduce some new operation. If such a man were asked how he was able to know this, he could not say, and he could not teach anybody else, but he knew how to do it just as the practical farmer knew the particular time at which to carry out a particular farm operation. No doubt the innate knowledge which English people now possessed would soon permeate Canadian circles as well.

SIR GEORGE R. PARKIN, K.C.M.G., LL.D., D.C.L., said that Edward Atkinson, one of the greatest statisticians America had produced, once told him that by making full use of modern appliances the work of seven men would put upon the table the food of one thousand, and those figures were verified by some rough calculations that he himself had made on the same subject. That left an enormous field for the other operations of life. Another equally important statement which Edward Atkinson made was that, under the conditions that existed in the United States before the War, and the rate of wages and the cost of transportation which then prevailed, the average working man in America could have his year's food transported 1,000 miles for the price of one day's work. Two figures like these, given by a thoughtful and authoritative statistician, did away with a very great deal of the pessimistic remarks that had been made in regard to the possibility of production not being sufficient to keep pace with consumption, taking into consideration the immense areas of the world still untilled. Personally, he did not believe that any one who was acquainted with the progress that science was constantly making would hold that view. He did not think it was possible to estimate the far-reaching influence which Dr. Creelman had exerted on the agriculture, not only of Canada, but also of the United States. When visiting one of the Universities in the Southern States of Canada, he found that the scientist in charge of the researches into cotton had been trained at the Guelph Agricultural College, and he was applying the methods he there learned to the special subject with which he was dealing. If a visit were paid to the agricultural colleges in Canada during the summer, the visitor would immediately be struck by the fact that trainloads of farmers visited the college for a day to see what was being done, while others came for a week or three weeks, or three months, with the object of going through a special course of lectures, and the regular student remained for three or four years. Teaching on a University level in agriculture was being brought down to the door of the farmer, and the farmer was being brought to the door of the University. The same state of affairs existed in some of the great American Universities. If a farmer found that anything went wrong with his crops, he immediately communicated with the University, which had a staff of men who enquired into such difficulties. There was an immense difference in that respect between new countries and the old countries. This country had depended so largely in the past

on experience that it had developed by a slow process a type of man with an instinct for the soil and for the things that belonged to the soil that was absolutely impossible in a country like Canada. It was the process of centuries of work, and such a man in this country did things which it was necessary in Canada or the United States to give a man special training to enable him to do. Some mixing of those two elements would, undoubtedly, be of advantage, not only to England, but to Canada. But if the agricultural population of this country was to be built up, the life of the agricultural people should be improved. The deadness of life in an agricultural village was destroying the elements which composed agricultural life, and it would be necessary to make the life more happy and interesting if the agricultural population was to increase. There was nothing which concerned the future of the Dominions more than the enlargement of the sphere of agricultural life in this country, because Canada could absorb any surplus population trained to agricultural work just as rapidly as it grew up. He thought a good deal of the super-excellence of English stock was due to the fact that men who had made large sums of money, either in the city or in different parts of the world, with the English love of country pursuits, took up the rearing of live-stock as a hobby, often raising the best breeds at a loss, and in that way they had developed the magnificent English stock which was the pride of the world.

Mr. A. H. Ashbolt (Agent-General for Tasmania), in proposing a vote of thanks to the author for his most interesting paper, said Dr. Creelman had proved why it was that only one individual, Joseph, had ever successfully cornered wheat. The author had shown how Canada and other parts of the world were able to produce large quantities of wheat whenever it was wanted, and had thus pointed out the danger to the modern world of attempting to imitate its Biblical ancestor.

Mr. E. T. Scammell formally seconded the motion, which was supported by Mr. Byron Brenan, C.M.G., who thanked the Chairman for his excellent speech in opening the discussion, the high level on which he started being followed by all the subsequent speakers.

Major H. H. Pounds, in supporting the motion, said that Professor Armstrong had referred to the very poor quality of the land in Australia. That all depended on the parts of Australia that he visited and the season of the year. Australia suffered from gentlemen who went there and inspected the country from the train, and then came back to this country and expressed their views with regard to the quality of the land. The western district of Victoria was one of the richest parts of Australia, in many places having a capital value of from £60 to £100 an acre, although 50 years ago the land was not considered worth £1 an acre. Many districts in New South Wales which thirty years ago were considered only fit for sheep rearing, now consisted of fields of waving corn, which fetched a rent of £5 to £10 an acre. There was a great deal of land in Australia which, although it was only fit for the growth of sheep at the present time, would develop into first-class wheat growing country. In Victoria a farmer, on the advice of a chemist who made an analysis of the soil, used a certain amount of artificial manure at a cost of 1*s*. 6*d*. an acre, and trebled his crop.

The motion was carried unanimously and the meeting terminated.

A FINNISH SNOW-MELTING MACHINE.

After ten years of experiment, a Finnish engineer has invented a snow-melting machine, which is being manufactured at Helsingfors. This machine is now used in Finland, Scandinavia and Russia; it is also patented in Canada and the United States.

The melting capacity of the machine is 26 or more cubic yards per hour, depending upon the size of the machine and the kind of fuel used. Cheap fuel, such as wood coke, coal, kerosène, and crude oil may be used. The smallest apparatus, weighing 500 pounds and requiring four men to keep it supplied with snow and fuel, uses when fired with coke, 200 pounds of fuel and melts 32 cubic yards of snow per hour. The machine utilizes 90 per cent. of the heat developed.

According to a report by the U.S. Consul at Helsingfors, the apparatus consists of an iron furnace, water-jacketed all around; a snow receiver, or hopper, surrounding the upper part of the furnace; a system of ducts by means of which the water from the melting snow is again forced into the snow, thus increasing the melting; a high-pressure fan driven by a small electric motor for creating a strong artificial draft and driving the heat developed out through the snow. The cooling of the furnace walls is accomplished by leading the snow water through the water jacket from which it is forced out again through jets into the snow.

The apparatus melts snow and ice. The dirt and gravel in the snow is automatically separated from the water outside the machine to avoid clogging drains or gutters.

The machine is used in Finland by street-cleaning authorities, banks, public buildings, large business houses, and property owners. The use of this machine reduces the cost of removing snow from the streets in Helsingfors by about 60 per cent.

DEVELOPMENT OF KAURI GUM INDUSTRY IN NEW ZEALAND.

Since the close of the war, more attention has been given to the development of the kauri-gum industry in New Zealand than at any time during the past five years, with the result that it seems probable that greater quantities of kauri gum and its by-products will be produced than hitherto.

There are very extensive kauri-peat swamps in New Zealand which have been placed at the disposal of interested parties by the New Zealand Government on a leased basis. The area which the Governor-General by Order-in-Council may set apart for the development of this industry is 10,000 acres, on a basis of leases for 42 years, no lease to exceed 3,000 acres. The lessees have to pay a low rental, and also a royalty on kauri oil and other valuable products obtained.

The New Zealand Peat Oils (Ltd.) have taken one grant of 3,000 acres, and are now developing it with reasonably good prospects of success, having tested four samples taken from different depths of the swamp which yielded an average of 29 gallons of crude kauri gum oil to the ton, with a yield of 4,300 cubic feet of gas per ton. This company propose to push the development of this industry.

It appears, from a report by the U.S. Consul-General at Auckland, that a new method of gathering and grading kauri gum has lately been undertaken, whereby kauri peat swamps that are thoroughly pregnated witd kauri gum in different stages of decomposition can be worked with reasonably good success. It is claimed that if this process succeeds, as indicated at present, more kauri gum can be secured from the deposits in the North Island than has been secured hitherto, though of an inferior grade.

It is proposed to grade this kauri gum into about three or four grades according to size, which means largely according to the degree of decomposition. It is claimed that any grade would be sufficient in quality for the manufacture of the lower qualities of varnishes and similar products, and would be exceptionally good for the manufacture of linoleums; and it is expected that these qualities of kauri gum can be produced in such quantities as to enable the product to be sold at a much lower price than formerly.

The production of kauri gum during the seven years previous to the beginning of the war averaged not far from 8,000 tons per year, while since that time it has scarcely averaged 4,000 tons, and during the year ended March 31st, 1919, only amounted to 2,338 tons. Of the output of 8,473 tons for 1914 the United States took 4,531 tons, the United Kingdom 3,335 tons, Germany 373 tons; while for the year ended March 31st, 1919, the United States took 1,371 tons, the United Kingdom 346 tons, Canada 572 tons, and Australia 49 tons.

GENERAL NOTE.

VICTORIA AND ALBERT MUSEUM.—The Exhibition of Textiles, now being held at the Victoria and Albert Museum, is of particular interest. The French Government have sent some of their rarest treasures, including three of the famous mediæval tapestries of Rheims Cathedral, and a series of Gobelins and Beauvais Tapestries from the French palaces. Besides French and Brussels tapestry, there is a very fine specimen of Mortlake work. There are also four admirable Gobelins panels, illustrating the Seasons, made for St. Cloud from the designs of Pierre Mignard, about 1686.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

MARCH 2.—CAPTAIN J. MANCLARK HOLLIS, Secretary to the Village Centres Council, "The Re-Education of the Disabled." LORD HENRY CAVENDISH BENTINCK, M.P., in the Chair.

MARCH 9 at 4.30 p.m.—WILLOUGHBY DEWAR, Hon. Secretary, Plumage Bill Group, "The Plumage Trade and the Destruction of Birds."

MARCH 16. — CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime." THE RIGHT HON. LORD JUSTICE ATKIN in the Chair.

APRIL 6.—PROFESSOR ARCHIBALD BARR, D.Sc., LL.D., M.Inst.C.E., "The Optophone."

APRIL 13.—PROFESSOR HENRY E. ARMSTRONG, Ph.D., D.Sc., LL.D., F.R.S., "Low Temperature Carbonisation and Smokeless Fuel."

INDIAN SECTION.

Fridays at 4.30 p.m.

APRIL 22.—LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

MAY 27.—WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

INDIAN AND COLONIAL SECTIONS.

(Joint Meetings.)

At 4.30 p.m.

FRIDAY, APRIL 15.—WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of

Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire." THE RIGHT HON. LORD MOULTON, G.B.E., K.C.B., F.R.S., LL.D., in the Chair.

TUESDAY, MAY 3.—SIR CHARLES H BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

DR. C. M. WILSON, "Industrial Medicine."

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

ERIC K. RIDEAL, M.B.E., M.A., D.Sc., Ph.D., F.I.C., "Applications of Catalysis to Industrial Chemistry." Three Lectures.

Syllabus.

LECTURE III.—FEBRUARY 28.—*Processes of Hydrogenation.*—Preparation and Purification of Hydrogen—Methane—Hexahydrobenzol—Oil Hardening—Synthesis of Ammonia—the Cracking of Oils—Synthetic Rubber.

Hydrolytic Processes.—Saponification—Glucose—Alcohol—Acetic Acid—Acetone and Ether.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

Syllabus.

LECTURE I.—MARCH 7.—Introductory and Historical—The Nature of X-rays—The Ubiquity of X-rays—Their Generation—Various Types of X-ray Tubes and their Efficiency—Importance of Wave-Form of Exciting Potential.

LECTURE II.—MARCH 14.—High Potential Generators—Open and Closed Coil Transformers—Influence Machines—Homogeneous X-rays—X-ray Measurements—Intensity and Wave-Length—Characteristic X-rays—X-ray Spectroscopy.

LECTURE III.—MARCH 21.—Applications of X-rays to Various Branches of Industry—X-rays in Medicine—Future Developments and Improvements.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25

MEETINGS FOR THE ENSUING WEEK.*

MONDAY FEBRUARY 28.. Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W., 4 p.m. Mr. A. Mansell, "Our Depleted Herds and Flocks, and Suggested Means for Resuscitating same and bringing them back to pre-war or Normal Standards."

TUESDAY, MARCH 1.. Sociological Society, 65, Belgrave Road, S.W., 8.15 p.m. Mr. C. Dawson, "Sociology and Progress."

Royal Institution, Albemarle Street, W., 3 p.m. Dr. A. Keith, "Darwin's Theory of Man's Origin in the Light of Present Day Evidence." (Lecture II.)

Alpine Club, 23, Savile Row, W., 8.30 p.m.

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. J. D. Johnston, "A Plain Traveller's Tale, Rome, Naples, etc."

WEDNESDAY, MARCH 2.. Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m. 1. Mr. C. A. Mitchell, "The Acidity of Ink and the action of Bottle Glass on Ink." 2. Mr. G. Van B. Gilmour, "The Detection of Adulteration in Butter by Means of the Melting-Point of the Insoluble Volatile Acids." 3. Messrs. S. H. Blichfeldt and T. Thornley, "Method and Apparatus for Routine Determination of Melting-Points of Fats and Fatty Acids."

Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Dr. W. H. Hatfield, "Automobile Steels."

United Service Institution, Whitehall, S.W., 5.30 p.m. Sir Charles Harris, "Finance of the Army."

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Prof. E. D. Ross "The Portuguese in India."

Royal Archaeological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Miss M. P. Perry, "The Stall-Work of Bristol Cathedral Church."

THURSDAY, MARCH 3.. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi W.C. 5.30 p.m. 1. Mr. J. W. W. Dyer, "Air-ship Fabrics." 2. Major T. O. Lees, "Parachutes."

Pottery and Glass Trades Benevolent Institution at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m. 1. Councillor W Bradford, "Glasshouse Processes and the Craft of the Glass Maker." 2. Mr. J. T. Wilson, "The Art and Method of Glass Cutting."

Royal Society, Burlington House, W., 4.30 p.m.

Child Study Society, at the Royal Sanitary Institute 90, Buckingham Palace Road, S.W. 6 p.m. Miss M. C. Buysman, "The Value of the Drama in the Training of the Child's Emotions."

Royal Institution, Albemarle Street, W., 3 p.m. Mr. F. B. Browne, "Mason Wasps." (Lecture II.)

China Society, at the School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Dr. A. N. J. Whymant, "The Psychology of the Chinese Coolie."

FRIDAY, MARCH 4.. Royal Institution, Albemarle Street, W., 9 p.m. Mr. W. A. Tait, "Severn Crossings and Tidal Power."

Philological Society, University College, W.C., 8 p.m. Sir Israel Gollancz, "Presidential Address."

Chemical Industry, Society of, and Mechanical Engineers, Institution of, (Joint Meeting), Storey's Gate, Westminster, S.W., 6 p.m. Mons. P. Kestner, "The De-gassing and Purification of Boiler Feed Water."

SATURDAY, MARCH 5.. Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Electricity and Matter." (Lecture I.)

Announcements intended for insertion in this list must be received at the SOCIETY'S Office not later than the Monday of the week preceding the Meeting.

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FRIDAY, MARCH 4, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 7th, at 8 p.m. (Cantor Lecture.) MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." (Lecture I).

WEDNESDAY, MARCH 9th, at 4.30 p.m. (Ordinary Meeting.) WILLOUGHBY DEWAR, Hon. Secretary, Plumage Bill Group, "The Plumage Trade and the Destruction of Birds."

CANTOR LECTURE.

On Monday evening February 28th, DR. ERIC RIDEAL, M.B.E., M.A., F.I.C., delivered the third and final lecture of his course on "Applications of Catalysis to Industrial Chemistry."

On the motion of the Chairman, a vote of thanks was accorded to Dr. Rideal for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

TWELFTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 23rd, 1921; THE RIGHT HON. LORD BLEDISLOE, K.B.E., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Beardsell, Sir William A., Madras, India.
Bejal, Shiv Shankar, Morar, Central India.
Boyce, Eduljees, M., B.A.; Jhan, United Provinces, India.
Bristow, Robert C., Cochin, S. India.
Chan Heang Thoy, J.P., Perak, Federated Malay States.
Hughes, William O., Bangor, N. Wales.
Kaul, Diwan Bahadur Sir Daya Kishan, K.B.E., C.I.E., Patiala.
Waring-Brown, Robert, A.M.I.A.E., Coventry.

The following Candidates were balloted for and duly elected Fellows of the Society:—

Beere, Orlando George, London.
Bent, Arthur, Manchester.
Ellen, Alfred Edward, London.
Fussell, G. E., London.
Millard, Walter S., Tunbridge Wells.
Rice, Lieut.-Colonel Sidney Mervyn, C.I.E., O.B.E., Poona, India.
Vasavada, Mohanlal Vallabhji, Morar, Central India.

The Trueman Wood Lecture on "The Present Position of Research in Agriculture" was delivered by SIR DANIEL HALL, K.C.B., F.R.S., Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture.

The lecture and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

NINTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 2ND, 1920.

PROFESSOR SIR JOHN CADMAN, K.C.M.G., D.Sc., in the chair.

THE CHAIRMAN, in introducing the author of the paper, said that petroleum was creating a certain amount of political interest at the present time, and it was not unnatural, therefore, that the Royal Society of Arts should consider the subject. How fuel oil might be burned, was a matter of very considerable interest and importance. In order to have a review of such a subject it was imperative that it should be given by someone who had done the work, who had actually burned oil, and who had designed apparatus for the burning of oil; and he knew of no one who was more capable of giving an account of that interesting side of the matter than Mr. Baillie.

The paper read was:—

FUEL OIL BURNING IN VARIOUS PARTS OF THE WORLD.

By Andrew F. Baillie,
Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company.

The subject of fuel oil is of great and growing importance, and I much appreciate the honour that your Society has conferred upon me by asking me to read a paper on this subject.

Fuel oil is frequently spoken of as "crude oil," but this is not correct, because the crude petroleum oil as it issues from the well contains certain light fractions of the gasoline and kerosene series, which it is not only desirable to extract from the crude by distillation on account of their higher values, but which if left in the crude oil and used as fuel, would be a wasteful procedure, and, further, would lower the flash-point. This flash-point has been very properly fixed for fuel oil by British Authorities, viz., Lloyd's Register of Shipping 150°F., London County Council 150°F., and British Admiralty 175°F.

The crude is, therefore, subjected to what is known as a "topping process," which is a distillation that cuts out those lighter fractions, leaving a product having a calorific value of approximately 19,000 B.T.U.'s per pound, that product being called "fuel oil."

Fuel oil is used firstly at the wells for raising steam in connection with the drilling of these wells. It is also used at the refineries as a heating agent under the stills, and also as a fuel for steam raising in various types of boilers. Fuel oil is further used in steamships, for generating steam in their boilers for supplying the main engines. Again, fuel oil is used for steam raising in numerous types of land boilers, also on locomotives and heating furnaces for metallurgical work.

In the consumption of fuel oil as a heating agent, it is first necessary to divide finely or atomise the fluid, so that it can be mixed with the necessary quantity of air, to make the resultant a combustible mixture. This process is called "atomisation", and is effected by means of apparatus called "oil fuel burners." These burners are manufactured by various engineering firms and come under three systems :—

(1) Air-Jet System.
(2) Steam-Jet System.
(3) Pressure-Jet System.

The first system uses air under pressure as an atomising agent. Low pressure air is blown from a motor-driven fan, although for special classes of work, such as the manufacture of electrical bulbs and other white glass ware, high pressure air has in the past been used, and is supplied by blowers or compressors. For some particular classes of work it has been found to be an advantage to take all the air for atomising and combustion through the burner, and in this case, the air is intermingled with the oil in the burner, the proportion being 207 cubic feet of air per lb. of oil. Thus, due to all the air being under control, an oxidising or reducing flame can be obtained at will. For other classes of work, the usual procedure is to take approximately 60 per cent. of air through the burners and induce the necessary extra quantity of air from the atmosphere to complete combustion.

The second system, viz., the steam jet system, uses steam under pressure as an atomising agent. It is usual to take this steam from an auxiliary stop valve on the boiler or from a tee on the auxiliary steam line, and reduce the pressure of this steam from boiler pressure to 15 to 25 lbs. per square inch. The proportion of steam required for atomising, say Mexican Fuel Oil, is approximately ·3 lb. of steam per lb. of oil, or, on the other hand, say 1½ to 2 per cent. of the total steam evaporated. Again, with the steam jet type of burner, the requisite amount of air to complete combustion is induced from the atmosphere.

The third system, viz., the pressure jet system, sprays the oil under pressure by means of a steam driven pump, and also uses steam temperature to thin or reduce the viscosity of the oil This latter system has been developed during the last 10 years to such an extent, that it is recognised as the most economical system for burning oil under land and marine boilers. In this system, oil is drawn from the storage tanks by means of a steam-driven pump through suction strainers, and pumped through fuel oil heaters and discharge strainers to the fuel oil burners. The object of the suction strainers is to collect any foreign matter in the oil so as to protect the suction and discharge valves of the pump. The object of the heaters is to raise the temperature of the oil to such a degree that oil, when intermingled with sufficient quantities of air, is suitable for combustion. The

object of the discharge strainers is that, after the oil is passed through the heaters, a certain amount of foreign matter is released, and is then trapped by these strainers so as not to choke the nozzle of the burners, as these nozzles are very fine, ranging from 1 to 2·5 mm. The hot oil under pressure issues from the burner in the form of a fine whirling mist, the process of which is termed "atomisation." The necessary air for combustion is introduced through special furnace fronts, which slightly preheat the air and impart to it a rotary motion in the opposite direction to the burner spray, in order thoroughly to intermingle and mix the oil spray and air supply, and so give complete combustion in the furnace. The quantity of air for combustion is under absolute control by means of dampers or air controls, fitted to the furnace front. These air controls can be fitted when using either natural or forced draught.

These three types of burners have their various uses; the steam jet being used generally for small land boiler plant, the pressure jet system for large boiler plant and marine purposes, and the air jet system for furnace heating and metallurgical work.

For comparative purposes, and assuming each of these systems tested under a steam boiler, we would obtain a thermal efficiency of approximately 78 per cent. for the steam jet system, 80 per cent. for the air jet system, and 85 per cent. for the pressure jet system.

As before mentioned, fuel oil is used as a heating agent under the boilers at the wells for producing steam for drilling purposes. The burners used in these cases are always the steam jet type of burner, as steam is always available from the boiler line, and again, as the last degree of economy has not to be studied at an oil well, it is a simple and useful tool, the working of which can be easily handed over to native labour. The burners used at the wells are usually those manufactured by Best of New York, Hammel, Von Boden Ingles and Urquhart.

The next step in the use of fuel oil is at the refineries, as applied to the stills and steam boilers. In refineries, where they have a heavy end to deal with, *i.e.*, a product approaching a liquid asphalt at high temperatures, it is usually the practice to burn a portion of this heavy end under the stills and boilers. This heavy end at a temperature of about 600° F. is run from the stills into storage tanks, which are lagged so as to eliminate a drop in the temperature of the fluid. From the outlet of the storage tank this heavy fuel is discharged by means of a steam-driven pump to an oil line in front of the boilers or stills. If the fluid is stored for any length of time, the temperature drops to say 350° F. It is, therefore, necessary to by-pass the fluid through another line, in which is installed an oil fired heater, much on the lines of a Dutch oven, so as to raise the temperature again to about 600° F. before the fluid reaches the supply line to boilers. This oil line is continued and discharged back to the main tank. It will, therefore, be noted that when using very heavy oils in the refineries, it is necessary to keep this oil continually circulated, otherwise, due to cooling of the heavy oil in the pipeline, great difficulty would be experienced. It may be interesting to note that with this heavy oil, in some cases where the stills and boilers are some distance from the storage, it is necessary, apart from running a steam line under the oil line and lagging them together, to instal boosting pumps, passing the heavy oil through various sections, until it reaches the fuel oil burners on the stills or boilers. With this very heavy fuel oil, it is necessary to spray it into the still furnaces or boiler furnaces at a pressure of 200 lbs. per square inch, and a temperature of 550° F.

It has been found that when using very heavy fuel oils, as described above, it is essential, in case of any shutting down of the plant, to have fitted a compressed air system to these oil lines, so that the line can be completely emptied of fuel, for if not the fuel would congeal and solidify in the pipes.

It will, perhaps, be questioned as to why this very heavy fuel oil should be utilised with all these difficulties attendant on its use. The reason for using this very heavy fuel oil is that at the present moment there is not a large enough world's market for its use, so that the percentage of this heavy fuel that cannot be marketed must be used in the refineries, otherwise the heavy fuel would become a drug on the refineries.

Fuel oil is used in steam ships as a heating agent in the ships' boilers for generating steam to drive the main and the auxiliary engines, and it is the general practice to adopt the pressure jet system of oil burning.

The fuel oil used must have a flash-point of over 150° F. closed to conform with Lloyd's and Board of Trade Regulations. In most cases the pumping and heating equipment is placed in the boiler room so as to be adjacent to the attendant, whose duties are in the stokeholds. In some cases, however, fuel oil having a flash-point as low as 79° F. has been used. In this case, to conform with Lloyd's and Board of Trade regulations, it was necessary to instal an isolated pump room extending from the upper deck to the ship's bottom. In this isolated pump room were placed the oil ends of the transfer pump and the fuel oil boiler supply pumps, also the fuel oil heaters. On the stokehold side of the isolated pump room were placed the steam ends of the transfer pump and the fuel oil boiler supply pumps. The reason for fitting this isolated pump room was that any vapours that might be evolved from the fuel oil heaters and boiler supply pumps would be contained in the isolated pump room and could not escape to the stokeholds; thereby eliminating danger of fires. To ensure further safety a steam driven suction fan was placed inside the isolated pump room and controlled by an extension spindle from the stokehold. This fan was run periodically to clear any gases that might have collected in the isolated pump room. A lift was also fitted for convenience of engineers and against any possible cause of gassing of men.

Fuel oil when used on board ship is usually stored either in double bottom tanks, cross bunker tanks, deep tanks or side pockets.

In the early days of oil burning, fuel oil was pumped from any of these compartments into a gravity supply tank placed on the main deck. From this supply tank the fuel oil gravitated to steam jet burners placed on the furnace fronts of the boilers. In those days the steam used for atomising ranged from anywhere between 5 and 10 per cent. of the total steam evaporated, usually nearer 10 per cent. It then dawned on the Superintendent Engineers that they were losing a large quantity of steam when using this class of burner, and it meant either carrying a large extra reserve of feed water or installing additional evaporators to cope with this loss of water. Steam jet burners for use on board ship were finally discarded, on account of the aforementioned difficulties.

The next step taken was to introduce compressed air jet burners for use on board vessel. As the horse-power of the steamers increased it was found that to supply sufficent air for atomising by means of air jet burners the auxiliary machinery necessary was very large and cumbersome, and took up a lot of valuable space in the engine room, and. furthermore, the maintenance charges were extremely heavy. For these reasons, the air jet system was discarded.

The system used to-day generally is the pressure jet system of oil burning, as already described.

The modern method of using fuel oil on board ship is as follows :—

Fuel oil is sucked from double bottom or other tanks by means of an oil fuel transfer pump discharging into two settling tanks placed on the main deck, each of these settling tanks having a capacity of 24 hours' supply. The tanks are fitted with heating coils, giving at least one sq. ft. of heating surface per ton of oil carried. The object of these heating coils is to reduce the viscosity of the oil in the settling tanks over a period, say, 20 hours, so that if inadvertently any water has contaminated the fuel oil it will settle out much more easily by aid of heat. It will be seen, therefore. that to obtain 20 hours' heating in each of these 24 hours' supply settling tanks, the fuel oil transfer pumps should be of such a size as easily to handle the day's supply in about four hours.

From the settling tanks the oil is sucked by means of boiler fuel oil supply pumps and thence discharged through heaters and filters to the burners on the boiler front as described before. At the bottom of the settling tanks drain cocks are fitted and connections led from these to a special pocket in the bilge in the boiler room. A connection can also be taken from the suction side of the fuel oil transfer pump and another from the discharge side with a connection overboard, so that the drainage water from the settling tanks can be discharged overboard by means of this pump.

When using Mex fuel oil, ·950 specific gravity, it has been found that with the exception of double bottom tanks it is not necessary to heat the oil to transfer it to the settling tanks. If double bottom tanks are used, however, it is always advisable to have steam heating coils in the vicinity of the suction pipes, so as to reduce the viscosity of the oil, as in this case the oil has to be lifted, whereas, in the case of

cross bunkers, deep tanks and side pockets, the oil will flow to the pump. In the settling tanks, with the same class of oil, it should be heated up to at least 100° F., as by this preliminary heating it takes a certain load off the fuel oil heaters as the oil has not to be heated up, say, from 40 to 260° F. Therefore, one operation is split up into two operations, viz., preliminary heating in the settling tank and a final heating in the fuel oil heaters.

It is sometimes necessary for oil companies to use a fuel heavier than that supplied to the ship owners, so as to ease accumulation of stocks at the refineries. This heavy oil is carried in the cross bunker adjacent to the boiler room and is handled through settling tanks, etc., to the burners. In this case the oil is usually heated up to about 135° F. in the cross bunker, and in the settling or measuring tanks to about 180° F., and finally in the fuel oil heaters to a temperature of 270° F., at which most efficient burning results are obtained.

To obtain actual running results on very heavy Mexican fuel oil the author had a trip across the Western Ocean some time ago. The following is a result of one of the series of tests carried out on one of the E.O.T. Co.'s vessels :—

Details of Boilers.	
Type of Boiler ...	Single Ended Scotch Marine
Number of Boilers ...	4
Length of Boiler ...	12′ 0″ mean.
Diameter of Boiler ...	16′ 3″
No. of Furnaces per Boiler ...	4
Diameter of Furnaces (inside) ...	40-7/16″.
Type of Furnaces ...	Deighton Corrugated.
Total Heating Surface, all Boilers ...	10,088 sq. ft.
Combustion Space per Boiler ...	598 cub. ft.
System of Draught ...	Howden Forced.
System of Fuel Oil Burning ...	Wallsend-Howden Pressure Jet.
Details of Main Engines.	
Type of Engines ...	Quadruple Expansion Tweedy Balance.
Diameter of Cylinders ...	28½″ x 41″ x 58″ x 84″.
Length of Stroke ...	54″.
Steam Pressure per sq. in. ...	220 lbs.
Details of Test.	
Duration of Test:	
Time occupied ...	120 hours.
Weather Conditions:	
State of Atmosphere (Barometer) ...	29.67″.
Temperature of Atmosphere ...	67° F.
Smoke at Funnel Top ...	Slight.
Fuel Oil:	
Specific Gravity @ 100° F. ...	.982.
Calorific Value in B.T.U. per lb. ...	18,500.
Tons of Oil consumed on test ...	195.
„ „ „ „ per day ...	39.
„ „ „ „ „ hour ...	1.625.
Lbs. of Oil consumed per hour ...	3,640.
„ „ „ „ „ „ per cub. ft. of combustion space ...	6.09.
„ „ „ „ per I.H.P. ...	.976.
„ „ „ „ per knot ...	324
Temperature of Oil in cross bunker ...	135° F.
„ „ „ „ Measuring Tanks ...	170/190° F.
Temperature of Oil at Burners ...	260/270° F.
„ „ Air at Fan ...	105° F.
„ „ „ „ Burners (top) ...	265° F.
„ „ „ „ „ (bottom) ...	225° F.
„ „ Stokehold ...	110/118° F.
„ „ Smokeboxes ...	655° F.
„ „ Uptakes ...	520° F.
„ „ Base of Funnel ...	475° F.

Pressure of Oil at Burners	100/120 lbs.
„ „ Air „ Fan	1-5/8″ to 1 3/4″.
„ „ „ „ Burners (top)	5/16″ to 1/2″.
„ „ „ „ „ (bottom)	11/16″ to 15/16″.
„ „ „ „ Base of Funnel	7/16″ to 1/2″.
Number of Burners in use	16
Size of „ „ „	No. 18.
Number of Heaters in use	3.
Double Strokes of Fuel Oil Pump per min.	8/9.
Water :	
Temperature of Sea	80° F.
„ „ Feed Water	235° F.
Tons of Water evap. on test (actual)	3096.6.
„ „ „ „ „ „ (from & @ 212° F.)	3201.7.
„ „ „ „ per day (actual)	619.32.
„ „ „ „ „ „ (from & @ 212° F.)	640.34.
„ „ „ „ „ hour (actual)	25.8.
„ „ „ „ „ „ (from & @ 212° F.)	26.68.
Lbs. of Water evap. per hour (actual)	57.803.
„ „ „ „ „ „ (from & @ 212° F.)	59.765.
„ „ „ „ „ sq. ft. of H.S. (actual)	5.73.
„ „ „ „ „ „ „ „ (from & @ 212° F.)	5.924.
„ „ „ „ „ lb. of. fuel (actual)	15.88.
„ „ „ „ „ „ „ „ (from & @ 212° F.)	16.419.
Factor of Evaporation	1.034.
Thermal Efficiency	85.73%.
Power Developed, etc. :	
Total	3729 I.H.P.
Revolutions per Minute	66
Speed in knots per Hour	11.23.

An interesting comparison was made by the American-Hawaiian Steamship Company some years ago when they carried out actual tests on one of their vessels, the s.s. "Arizonan," burning coal and fuel oil respectively.

The results obtained are given below :—

COMPARATIVE DATA : COAL *v.* OIL FUEL—S.S. "ARIZONAN" ON TWO VOYAGES.

AMERICAN-HAWAIIAN STEAMSHIP COMPANY.

Covering passages from New York, Pacific Coast Ports, Hawaiian Island Ports, and return to Philadelphia, via Straits of Magellan out and home.

Gross Tonnage : 8,672, Twin Screw, Three Boilers, Howden Forced Draught, 215 lbs. Pressure, Quadruple Expansion Engines.

	Mean Displacement out, in Tons.	Mean Displacement home, in Tons.	Steaming Time. Days.	Round Voyage. Days.	Average Speed Knots.
Voyage No. 3—Using Coal ...	16,882	16,660	143.33	186	9.01
Voyage No. 4—Using Oil ...	15,930	17,280	125.25	161	9.95

The actual cost of fuel consumed on those voyages was practically the same.

It will be noted that when using fuel oil against coal the average speed of this vessel was increased almost by one knot per hour, and that 25 days were saved on the round voyage, 18 days were saved owing to the increased speed, and 7 days were saved owing to reduction in time of fueling oil against coal. The boilers and engines on both of these tests were operated at their maximum capacities. The savings in victualling, manning and also the increased freight earnings, etc., together with the days saved per round voyage, amounted to approximately £4,000 per trip.

Fuel oil is largely used as a heating agent on land boilers in the various countries where oil is directly competitive with coal, and is used principally in electric power stations and mills. These plants are in-

variably fitted with the pressure jet system of oil burning, due to its acknowledged economy over other systems.

In this country we have a few cases where manufacturers have converted their boilers solely from coal burning to oil burning. Again, in these cases they have been always carrying a heating load and manufacturing products which require essentially a given volume of heat at a given temperature over a specific time.

When coal firing, owing to the fact that the fires have to be periodically sliced and cleaned, the steam fluctuates so much that the products the manufacturers were aiming at were not as perfect as they desired. It was, therefore, suggested that fuel oil be adopted, not so much a question of price, but because by turning out a better quality product they could afford to pay a higher annual fuel bill. These suggestions were in some cases adopted, and the desired results obtained.

It may be interesting to consider the figures obtained at a large London factory, where their Lancashire boilers were converted from coal firing to oil firing, as follows :—

a great point made was the cleanliness, freedom from dust and ashes, etc., and also, in the crowded parts of London, the fact of the cartage being considerably reduced, probably by 70 per cent.

Locomotives in South America, the United States and Eastern Europe have for many years been running on fuel oil in place of coal.

As far back as 1890 Mr. Urquhart converted a large number of locomotives from coal to oil firing on the Russian rail roads, using Mazout as fuel.

Of recent years, the principal change over has taken place on the Mexican rail roads, where practically all the rail roads have been converted. In December, 1910, Mexican rail roads were running on coal only; in June, 1911, 20 per cent. had converted; in December, 1911, 80 per cent. had converted; in June, 1912, 90 per cent. had converted, and by December, 1912, the whole of the rail roads were converted from coal to oil firing.

In locomotive practice the steam jet system of atomising is favoured, probably owing to its simplicity, and to the fact that it only required a tee connection off the

	Coal.	Oil.
Duration of test	24 hours.	12 hours.
Calorific Value of Fuel	11,451 B.T.U.'s.	18,750 B.T.U.'s.
Quantity of Fuel consumed per Hour ...	889 lbs.	955.6 lbs.
System of firing	Hand Firing	"White" pressure system.
Pressure of Oil at Burners	—	80 lbs.
Temperature of Oil at Burners	—	230° F.
Average Steam Pressure	56 lbs.	68 lbs.
Average Feed Water Temperature	126° F.	130° F.
Quantity of Water evaporated per hour from and at 212° F.	6,419.6 lbs.	13,809 lbs.
Water evaporated per lb. of Fuel from and at 212° F.	7.221 lbs.	14.44 lbs.
Quantity of Water evaporated per hour per sq. ft. of Heating Surface from and at 212° F.	3.675 lbs.	7.945 lbs.
Temperature of Gases at Base of Stack ...	615° F.	485° F.
Temperature of Boiler House	100° F.	75 85° F.
Thermal Efficiency	60.91%	75%
Percentage of Rated Evaporation	100.0	215.

It will be noted, in the comparative tests that when using fuel oil the evaporation per lb. of fuel was doubled and again, the boiler rating was increased over 100 per cent.

The temperature of the boiler house was also much lower.

Again, in these manufacturing factories

steam line for jetting purposes, and again, steam is always available in the round house for lighting up.

I understand the pressure jet system of oil burning was tried on some of the Indian rail roads some five or six years ago. The system was found to be economical, but, on the other hand, the heating and pumping

unit was too cumbersome to be comfortably fitted into the cab of the existing locomotive. The objection on this score was so strong that the pressure jet system was discarded in favour of the steam jet. It may be interesting to view the following figures, which is a statement showing comparative tests with coal and oil in the Interoceanic Railway of Mexico. This railway connects Vera Cruz on the Gulf of Mexico with the Port of Acapulco on the Pacific, and has a total mileage of 1,035.

adjoining country casued in this way.

In locomotive practice the cost of handling is also reduced.

We learn that in the States some few years ago oil could be handled from tank cars to storage tanks and thence to locomotives for about ·03 cents per ton, while the average for handling coal ran about 5 cents per ton.

Again, from experience, it is stated that the usual wastage of coal in handling between shipment and consumption is from 8 to 10 per cent., whereas, when handling fuel oil this loss is entirely eliminated.

COMPARATIVE TESTS WITH COAL AND OIL INTEROCEANIC RAILWAY OF MEXICO.

Test No.	Time Running.	Miles Run.	Speed.	Lbs. Water Evap.	Lbs. Fuel used.	Water evap. per lb.	Gross Weight of Train in Tons of 2,000 lbs.
				Coal.			
	h. m.						
1.	3 18	35.4	10.73	43,277	8,580	5.04	173.52
2.	3 28	35.4	10.20	41,575	8,140	5.11	173.50
3	3 29	35.4	10.17	42,985	8,580	5.00	172.37
4.	3 34	35.4	9.92	46,106	10,340	4.46	173.64
5.	3 38	35.4	9.75	43,586	11,220	3.88	184.83
				Oil.			
1.	3 04	35.4	11.53	50,612	4,397	11.51	173.77
2.	3 16	35.4	10.81	46,699	4,390	10.64	176.11
3.	2 53	35.4	12.28	39,046	4,073	9.59	175.62
4.	2 33	35.4	13.88	41,591	3,833	10.85	163.74
5.	2 47	35.4	12.73	45,305	4,157	10.90	174.85

SUMMARY.

Time getting up 180 lbs. steam from cold ... ... Coal—98 minutes.
Time getting up 180 lbs. steam from cold ... ... Oil—70 minutes.
Improved Speed with Oil over Coal (average) ... ... 20.2 per cent.
Improved evaporation per lb. Oil ... ... 6.05 lbs. or 130 per cent.
Pounds of Coal per 100 ton miles ... ... 15.07 lbs.
Pounds of oil per 100 ton miles ... ... 6.85 lbs.

One valuable feature of the use of fuel oil on foreign railways is the immunity it affords from the number of compensation claims arising out of fires taking place due to the sparks from wood or coal engines setting fire to crops and forests. Some years ago the State Forester to the Public Service Commission of the United States strongly recommended a prominent American rail road to convert from coal to fuel oil firing in view of the frequent devastation of the

There are no men required to load up the engine or clean out ash pans. There are no ash pits to empty, or ash to be loaded up and hauled away to be unloaded on to waste ground. Fuel oil practically handles itself, and the man attending to the water pumps can also supervise the supplies of fuel to the locomotives.

In this country tests have recently been carried out on oil firing the Watt type

locomotive of the London and North Western Railway, this locomotive being in daily service between London and Birmingham. It may interest you to know that 450 gallons of oil were consumed between London and Birmingham to pull a train having a total weight of approximately 400 tons. The mileage from London to Birmingham is 115, so that the consumption runs out at less than one gallon of oil per 100 ton mile.

In this locomotive the burner was placed at the tube plate end of a special extension below the foundation ring of the firebox taking the place of the ordinary ashpan. The flame is projected towards the rear end of the firebox, and thence deflected towards the tube plate. The ashpan has a false bottom formed of brickwork slabs curved towards the back end in order to deflect the products of combustion upwards. The sides of the ashpan are lined with fire-brick to a point just above the foundation ring, otherwise the whole of the heating surface of the firebox is available for steam generation.

Three burners are installed. The one in the centre, the main burner, is used when the locomotive is working at full load; the two wing burners are controlled by one valve and are of a much smaller capacity, only being used when standing with steam up.

The arrangement of these burners gives the best path to the flame and the products of combustion round the firebox to the tube plate so that in actual practice the whole of the firebox is filled with flame.

A low arch is provided immediately over the burners in order that the heat of the first ignition of the oil spray may be concentrated and complete combustion effected as soon as possible. A small arch below the coal firing door deflects the rush of flame from this door and another arch across the centre of the firebox deflects the flame all over the firebox surfaces and distributes evenly over the tube plate.

A certain quantity of air is admitted through the burner casings. This air is not under control and only provides the oxygen necessary for the initial combustion of the spray. A further portion of air enters the furnace from a number of small holes in the firebrick false bottom of the ashpan a few feet in front of the burner nozzle. Additional air enters through a damper placed in front of the firebox and is heated by its contact with the hot surfaces of the ash pan exposed to the flame. This air is then passed into the furnace, close to the back plate of the firebox, and being highly heated in its passage is admitted to the furnace so as to provide the necessary oxygen to complete the combustion in the already ignited oil spray.

The steam for atomising is taken from the boiler line through a reducing valve, into a receiver, at a pressure of 15 lbs. per sq. inch. This receiver acts as a water collector, and is blown out periodically, so as to ensure dry steam reaching the burner. In the Scarab application of oil burning, before this steam reaches the burner it is passed through a calorised steel pipe, placed in the bottom of the firebox, in order to superheat the steam. It is stated that this calorised pipe is non-oxidisable at high temperatures, and has a very much longer life than an ordinary untreated steel pipe. A Tee piece and control valve are fitted in the steam line, so that the engine can be started up from cold, either by taking steam from another locomotive or by means of compressed air in the round house. Steam is also led to a heater on the out-board side of the tank on the tender, so that oil may be heated up to reduce its viscosity between the oil tank on the tender and the burner on the locomotive. On the pipeline between the heater and the burner a steam connection is fitted, so that at the end of the day the line can be cleared of oil, otherwise difficulties might be found the next day when attempting to start up, due to the oil becoming much more viscous at the low temperature throughout the night.

The main oil tank is placed on the tender, and is fitted with a steam heating coil close to the outlet, so as to provide sufficient heat to enable viscous oil to flow freely from the tank to the heater.

A thermometer is placed in the oil pipe-line, so as to register the temperature of the oil, which acts as a guide to the fireman.

It is also advisable in cold countries, apart from the heating of the oil in the storage tank and in a special heater on its way from the storage tank to the burner, to have these oil pipes steam jacketed between the control on the cab and the burners themselves, so that the oil reaches the burners at a temperature of at least 100° F.

In the early years of this century, a

French engineer introduced the subject of oil as an auxiliary, to which in the past little attention had been paid. The main advantages of auxiliary firing, he remarked, lay in being able to obtain at will a large increase in the power of boilers. The combustion of the petroleum does not in any way prejudicially affect that of coal; in fact, by the introduction of jets of petroleum, the condition and efficiency of combustion are improved by more completely mixing the gases. It is, therefore, not correct to consider the evaporative power of coal as identical, when passing from ordinary to auxiliary firing, as the coal end efficiency should be largely increased.

Admitting this as a principle, and supposing the quantity of water evaporated by the coal to be constant, the extra evaporation, due to the better mixing of gases, is credited to the petroleum.

Several evaporative trials were made with coal only and coal and oil firing on the same boiler of a French Navy ship. When burning coal alone at the rate of 18·8 lbs. of coal per square foot of grate area per hour, and when burning coal and oil, in different proportions of oil at the rate of 21·3 and 21·7 lbs. of mixed fuel per square foot, the results were as follows:—

Test No.	Fuel used. Coal.	Fuel used. Oil.	Lbs. of Fuel per sq. ft. of grate area.	Water evaporated per lb. of Fuel used.	Remarks.
1	100%	—	18·8	9·05	—
2	55%	45%	21·3	11·34	25% evaporative increase over No. 1.
3	36%	64%	21·7	14·12	56% evaporative increase over No. 1.

These tests are encouraging and serve as a basis for further experiment, but the question was not developed until about six years ago, when power station engineers started taking a keen interest in the subject.

The theory was that a poorer class of coal could be used in conjunction with oil fuel than could be burned satisfactorily under the boilers, due to the fact that the poor classes of coal tended to cake on the links of the chain grate stokers, thereby retarding the necessary quantity of air from being drawn through the bars to complete combustion.

The result was that the poor classes of coal were merely covered with a smouldering mass, which travelled slowly along the bars and was dumped into the ashpit as a partly consumed coal. This ash, on analysis, would probably have contained a very high percentage of combustible matter, thereby causing a very much higher quantity of coal to be burned per hour to maintain, say, rated evaporation.

When fuel oil is applied, the theory is that owing to the almost perfect combustion obtained thereby, the combustible gases rising from the coal fuel bed were quickly ignited, causing the top of this mass to become much more incandescent, thereby tending to airify the bottom mass, which would then allow sufficient air to be drawn through to complete the combustion of the rest of the poor class coal.

Sufficient interest was taken in this theory for a large London power station to give their sanction for tests to be carried out under one of their coal-fired Stirling water-tube boilers. One burner was introduced into each side of the boiler, approximately 25% from the back of the grate, the burners being opposite one another. The fuel oil was stored in an overhead tank, capable of holding three or four days' supply. The oil then gravitated to the burners, which were of the Kermode steam jet type, operating with steam as an atomising agent, at a pressure of about 25 lbs. per square inch.

The coal test was carried out on a nutty slack, having a calorific value of 10,400 B.Th.Us., and a boiler efficiency of 69·25% was obtained. The temperature of the combustion chamber was 2,648° F., and uptake 660° F.

The final of a series of experimental mixed-burning tests was carried out on a nutty slack, having a calorific value of 10,300 B.Th.U.s, and Mexican fuel oil having a calorific value of 18,750 B.Th.Us. A boiler efficiency of 74% was obtained, and the temperature of the combustion

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Three burners are installed. The one in the centre, the main burner, is used when the locomotive is working at full load; the two wing burners are controlled by one valve and are of a much smaller capacity, only being used when standing with steam up.

The arrangement of these burners gives the best path to the flame and the products of combustion round the firebox to the tube plate so that in actual practice the whole of the firebox is filled with flame.

A low arch is provided immediately over the burners in order that the heat of the first ignition of the oil spray may be concentrated and complete combustion effected as soon as possible. A small arch below the coal firing door deflects the rush of flame from this door and another arch across the centre of the firebox deflects the flame all over the firebox surfaces and distributes evenly over the tube plate.

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French engineer introduced the subject of oil as an auxiliary, to which in the past little attention had been paid. The main advantages of auxiliary firing, he remarked, lay in being able to obtain at will a large increase in the power of boilers. The combustion of the petroleum does not in any way prejudicially affect that of coal; in fact, by the introduction of jets of petroleum, the condition and efficiency of combustion are improved by more completely mixing the gases. It is, therefore, not correct to consider the evaporative power of coal as identical, when passing from ordinary to auxiliary firing, as the coal end efficiency should be largely increased.

Admitting this as a principle, and supposing the quantity of water evaporated by the coal to be constant, the extra evaporation, due to the better mixing of gases, is credited to the petroleum.

Several evaporative trials were made with coal only and coal and oil firing on the same boiler of a French Navy ship. When burning coal alone at the rate of 18·8 lbs. of coal per square foot of grate area per hour, and when burning coal and oil, in different proportions of oil at the rate of 21·3 and 21·7 lbs. of mixed fuel per square foot, the results were as follows:—

mass, which travelled slowly along the bars and was dumped into the ashpit as a partly consumed coal. This ash, on analysis, would probably have contained a very high percentage of combustible matter, thereby causing a very much higher quantity of coal to be burned per hour to maintain, say, rated evaporation.

When fuel oil is applied, the theory is that owing to the almost perfect combustion obtained thereby, the combustible gases rising from the coal fuel bed were quickly ignited, causing the top of this mass to become much more incandescent, thereby tending to airify the bottom mass, which would then allow sufficient air to be drawn through to complete the combustion of the rest of the poor class coal.

Sufficient interest was taken in this theory for a large London power station to give their sanction for tests to be carried out under one of their coal-fired Stirling water-tube boilers. One burner was introduced into each side of the boiler, approximately 25% from the back of the grate, the burners being opposite one another. The fuel oil was stored in an overhead tank, capable of holding three or four days' supply. The oil then gravitated to the burners, which were of the Kermode steam jet

Test No.	Fuel used.		Lbs. of Fuel per sq. ft. of grate area.	Water evaporated per lb. of Fuel used.	Remarks.
	Coal.	Oil.			
1	100%	—	18·8	9·05	—
2	55%	45%	21·3	11·34	25% evaporative increase over No. 1.
3	36%	64%	21·7	14·12	56% evaporative increase over No. 1.

These tests are encouraging and serve as a basis for further experiment, but the question was not developed until about six years ago, when power station engineers started taking a keen interest in the subject.

The theory was that a poorer class of coal could be used in conjunction with oil fuel than could be burned satisfactorily under the boilers, due to the fact that the poor classes of coal tended to cake on the links of the chain grate stokers, thereby retarding the necessary quantity of air from being drawn through the bars to complete combustion.

The result was that the poor classes of coal were merely covered with a smouldering

type, operating with steam as an atomising agent, at a pressure of about 25 lbs. per square inch.

The coal test was carried out on a nutty slack, having a calorific value of 10,400 B.Th.Us., and a boiler efficiency of 69·25% was obtained. The temperature of the combustion chamber was 2,648° F., and uptake 660° F.

The final of a series of experimental mixed-burning tests was carried out on a nutty slack, having a calorific value of 10,300 B.Th.U.s, and Mexican fuel oil having a calorific value of 18,750 B.Th.Us. A boiler efficiency of 74% was obtained, and the temperature of the combustion

heat is applied in a similar manner to that of a metal melting furnace.

The tank type of furnace consists of a large open tank with an arched roof, of a capacity ranging from 2 to 150 tons. The mixture of sand and cullet, i.e., scrap broken bottles, is fed in through a charging door in the end or side of the tank, and the burner flames play across the top of the charge until it fuses. The molten glass is then drawn off from the tank at the opposite end to the burners, and is blown into bottles. Tanks are used for the manufacture of blue, black, amber and pale green glass.

The temperatures in the pot furnaces and tanks are approximately 2,750°F. and 2,400°F. respectively.

The consumption on a tank furnace is 37 lbs. oil per 100 lbs. finished glass produced.

Another field in which fuel oil is used is steel melting. The following results were obtained by an Italian firm using fuel oil for heating open hearth Siemens-Martin steel furnaces:—

The furnaces are basic of 65 tons capacity, 4 in all, 11 metres long by 5 metres broad by 3·4 metres high, at the centre of the arch. There are five charging doors, and each section is built on the separate arch principle. The furnaces are charged with molten pig iron from a large mixer.

The temperature obtained is 1650° C., and an output of 150 tons of steel per 24 hours per furnace on an oil consumption of 16·5 to 18·75 tons, which gives 11 to 12·5% fuel consumption. The air for atomisation in this case was four kilos per sq. cm.

The above furnaces are some of the types of furnaces to which fuel oil is being applied. There are also many more classes of heat treatment of materials to which fuel oil is, and can be, applied at the present time.

DISCUSSION.

Prof. J. S. S. Brame, in opening the discussion, said several sections of the paper must have impressed upon those who had listened to it what a great deal could be done, not only from the point of view of steam raising, but in other industrial directions, by the use of oil fuel. Some people said that it was a criminal waste to burn oil for steam raising and heating purposes, and at first sight possibly it did so appear, because of the enormous quantity of very valuable products that could be obtained from oil by processes of distillation. There was, however, another phase to that question. It was perfectly true to say that a good oil should be treated as it deserved to be treated, and that the very last possible ounce of value should be obtained from the oil; but he thought the author would agree with him when he said that there was a large number of oils of common occurrence which did not lend themselves to treatment beyond the recovery of the lighter distillates, which served for petrol and kerosene, and which after that treatment would not be suitable for direct use with any of the present internal combustion engines, although under those circumstances much better use could be made of the heavy oil than could be made of it in open burning. Personally, he thought that, desirable as it would be for every drop of oil to be refined to the last degree, there would still be produced in the world large quantities of oil which would give a residual fuel oil that could be most economically employed as a steam-raising or heating agent. The author had very briefly dealt with the important methods of atomisation, air atomisation, steam and pressure systems, and he had shown the reasons why, certainly for marine practice, the pressure system had been practically universally adopted. He could not agree with some of the author's figures as to steam consumption; they were too low. The average figure which had been obtained from extensive tests by the United States Navy Fuel Board, some few years ago, had been 0·6 lb. steam per lb. of oil atomised—a figure considerably higher than the one quoted in the paper. It was to be remembered that the atomising steam was entirely lost, and, although in the past very extravagant claims had been made that steam had assisted in the combustion of the oil—in fact, claims showing an evaporation as high as 47 lbs. of water per lb. of oil—those claims had been entirely dissipated. It was well known that under the best conditions not more than 16 lbs. of water per lb. of oil was likely to be obtained. In order to explain those extraordinary results some wonderful action of the steam with the oil had been postulated. As far as he could see, it had never been shown that the steam, which in the first place must undergo dissociation before it could re-associate in any way with the oil, did promote combustion. To his mind it was displacing air which might more valuably be used for supporting the combustion. A very important aspect of the use of steam was from the point of view of the heat economy of the system. Steam for atomising was sent into the furnace at a temperature probably not exceeding 220° or 240° C., and flue gases were sent out which were always considerably hotter than the ingoing steam, and a lot of sensible heat was lost in the steam—far more than when pressure atomisation or air injection was used. There was another point closely connected with the question of

1917 for furnace purposes was for billet heating in connection with the manufacture of shells. In pre-war times, the principal consumers were glass bottle manufacturers, and rivet, bolt and nut makers.

Fuel oil is largely used as a heating agent for billet heating for drop stampings.

The furnace is usually of a rectangular shape fitted with an air jet type burner at one end, and a counterblast at the other end, the handling doors being in the sides.

The air pressure is usually obtained from a fan giving a pressure up to 28" W.G.

Both the air and oil supply should be preheated by the exhaust gases on their way to the burner.

The oil consumption per 100 lbs. of metal heated for drop stamping is approx. 9 lbs.

Again, the nut and bolt makers are large users of fuel oil.

The construction of the furnace is on similar lines to that of a billet heating furnace, except that it is usual on a bolt-making furnace to work two sides, and in some cases, four sides are worked. The round bars for the bolts are cut to length cold, then the pins, as they are termed, are put each separately into a hole in a special brick let into the side of the furnace. Thus only the end to form the bolt head is heated. The nuts are made from flat bar material heated the full length that it will go into the furnace. The nuts are then stamped off hot.

The consumption on a nut making furnace gives approximately 4 lbs. oil per 100 lbs. metal heated, and a bolt making furnace 4·5 lbs. oil per 100 lbs. metal produced.

A test on a bolt making furnace 9" by 12" by 20" in the Midlands gave 400 to 500 gross of $\frac{3}{4}$" to 1" dia. bolts per week, on a consumption of 300 gallons of oil.

The rivet heating furnace is another type of furnace to which oil has been applied successfully. A large Clyde firm on a three weeks' test turned out 4 tons 8 cwt. of heated rivets on a 118 gallon consumption of oil, which gives 10·3 lbs. oil per 100 lbs. rivets heated.

The outstanding features in using oil on the above types of furnaces is the increased production, which is 100% to 400%, depending on class of work and conditions, also the great saving in floor space.

The metal melting industry offers great scope for the use of fuel oil, and it is used extensively on brass, aluminium and cast iron melting furnaces.

The brass and aluminium is usually melted in lift out type of furnaces. These consist of a plumbago crucible set in a cylindrical furnace, in the case of a single furnace, and an air jet burner is applied tangentially at the bottom so that the flame rises in a spiral round the pot. In the case of a battery of pots, the burners are placed at both ends of the battery.

For larger type brass casting work a tilting furnace is employed. This consists of a pot holding 600 lbs. in a furnace, the whole mounted on trunnions, so that the pot can be tilted for pouring.

For still larger melts an open hearth type of furnace is employed, holding about three tons of metal. The burner in this case plays across the top of the metal, and the molten metal is removed by means of ladles.

The following results have been obtained on the above types for gun-metal melting :—

Tilting furnace—10 lbs. oil per 100 lbs. metal (finished).

Open hearth furnace—10 lbs. oil per 100 lbs. metal (finished).

Lift out furnace—12·5 lbs. oil per 100 lbs. metal (finished).

The chief advantages in using oil are increased output, increased life of pots and decreased metal losses.

Cast iron melting and steel making is usually carried out on a "Stock" convertor furnace. This consists of a large egg shaped wrought steel receptacle, brick lined and balanced horizontally on trunnions. The charge is $\frac{1}{2}$ ton to 3 tons of pig iron. The oil is forced into the burner hot at a pressure of about 40 lbs. The air for atomisation is pre-heated, and blown in at a pressure of $1\frac{1}{2}$ to 2 lbs. After the pig iron has reached the necessary state of fluidity the oil is shut off and air alone at a pressure of 3 to 4 lbs. is blown through, which converts the pig iron to steel.

On this class of furnace the oil consumption is 15 lbs. per 100 lbs. for melting only, and 40 lbs. per 100 lbs. for total fuel consumption including lighting and heating up.

A large number of glass works use fuel oil for melting purposes. It is applied both to pots and tanks. The pot furnace from which white or flint glass is produced, consists of an earthenware pot in which the sand is placed to form glass. The

heat is applied in a similar manner to that of a metal melting furnace.

The tank type of furnace consists of a large open tank with an arched roof, of a capacity ranging from 2 to 150 tons. The mixture of sand and cullet, i.e., scrap broken bottles, is fed in through a charging door in the end or side of the tank, and the burner flames play across the top of the charge until it fuses. The molten glass is then drawn off from the tank at the opposite end to the burners, and is blown into bottles. Tanks are used for the manufacture of blue, black, amber and pale green glass.

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the use of the heavy residues for burning. The author had pointed out how very difficult it was to burn some of those heavy asphaltic residues which had to be dealt with in Mexico, and the great precautions which had to be taken against allowing the temperature to drop, clearing pipelines with compressed air and so on when the plant was shut down. That made one realise that if some of those very heavy oils were refined until such a point as that was reached, for a large number of the applications of fuel oil they would be perfectly inadmissible: any such elaborate system could not possibly be installed, for instance, for marine purposes or even for general industrial purposes. The author had also referred to the use of coal and oil in the French Navy and gave certain figures. In our own Navy we had been accustomed to the use of coal with oil long before there was the all-oil fired ship. It had been a great step which had been taken some years ago—he believed by Mr. Churchill—in introducing the very large battle cruiser which was fully oil fired. The great speeds which had been attained by our large battle cruisers and battle ships burning oil alone, in conjunction with turbine engines, had led to a marvellous development in the Navy practice. He would like to call attention to the figures which the author had given in connection with the comparative results for coal and two lots of coal and oil in the French Service. He thought a word of warning was necessary. The author showed that in the one case there was 25 per cent. better efficiency than with coal alone, and in the second case 56 per cent. better efficiency. But he would direct attention to the fact that the net calorific value of the fuel burned was very much higher in the case of the coal and oil in each case; in fact, some rough figures which he had worked out showed that where there was 55 per cent. of coal and 45 per cent. of oil the calorific value of that mixture was about 22 per cent. better than the calorific value of the coal. In the case of the 36 per cent. coal and 64 per cent. oil, the mixture had about 33 per cent. better calorific value than the coal alone. That had to be taken into consideration when the better efficiency obtained by the combined fuels was considered.

Dr. W. R. Ormandy remarked that the author had gone a long way to show many of the advantages which attached to the use of oil. It had been said, when reference had been made to posterity, "What has posterity done for us?" and the answer was, "Very little—almost nothing." But it could be said that posterity would have a great deal to say about what we had done, and when posterity came to deal with the subject of the utilisation of oil fuel, and it divided the sheep from the goats, he thought the author would be a goat, because posterity would say that he had so admirably pointed out how oil could be used that he had tempted people to use it in the way in which it should not be used, and it might even consign him to a place where the temperatures attained were higher than those attained by oil fuel! The previous speaker had stated that there were large amounts of oil produced in the world which were not suited for much more than being burned under boilers; and he (the speaker) had to admit that he had been very much under that impression until comparatively recently, when he had heard that the particular oils which he had in mind, namely, the Pannuco oils of Mexico, having a very high gravity, were being distilled, and distilled so successfully that there were being produced from them very large yields of lubricating oils, which were being sold at little below the prices—which had up to that time been considered unapproachable—of the Pennsylvania oils. It might have been noticed in the newspapers of that day that there was just a prospect that America might put an embargo upon the exportation of oil. If America were to do that to the uttermost limits, and were to prohibit the exportation of lubricating oil, it would be a very serious thing for Europe, and it certainly behoved us in this country to take steps at an early date for making arrangements whereby, should the power which the American Government proposed to take upon themselves be exercised, we should at any rate be in a position to supply our own requirements with something which was almost, if not quite, as necessary as the very food we ate, for there was not an engine that could run, and not a wheel that could turn round without an adequate supply of lubricants. Indeed, the shortage of lubricants had gone further towards undoing the Germans at an early stage of the war than almost anything else. He did not entirely agree with the previous speaker in adumbrating the advisability of using oil for burning except under exceptional circumstances. There was no doubt about it that for marine use the auxiliary advantages of cleanliness, reduced labour, saving in time in fueling the boat, and increased speed of journey, enabled a shipowner to use oil at a price very much greater than was conveyed by the difference in the heat value of the fuel. Theoretically a ton-and-a-half of coal did as much as a ton of oil, but in actual practice it might be said that a ton of oil would do as much as two tons of average coal, because one could work more efficiently and get the right proportion of air more accurately than with coal. But the auxiliary advantages enabled the shipowner to pay very much more than twice the price for oil that he could pay for coal, and Lord Pirrie had voiced a warning in the Press that the rate at which boats were being converted to burning crude oil was going to lead to trouble in the near future, and he (the speaker) thought

that possibly a word of warning was necessary in view of the very admirable manner in which the author had brought out the advantages that were derived from the use of oil. In a great many cases it was worth while discussing auxiliary oil for the advantages which it conveyed, and not the least of those advantages was the peculiar state of the coal mining industry. He did not know whether it was general knowledge that a certain number of the large London hotels had arranged matters so that they were independent of the outside community in the direction of heating, generating electric light, refrigerating and the like. The Post Office also, in their boosting stations on the telephone lines, would not use electricity from the nearest town, nor would they use steam. They were putting down semi-Diesel engines, or internal combustion engines driven with oil, each one provided with oil storage sufficient to last for several months, in order that they might be independent. There was no doubt about it that in many directions the freedom from the possibility of the cutting off of supplies suddenly led to the use of oil even at a cost which was greater than that attached to the use of coal.

Mr. W. H. Patchell said that the author had given a most excellent and practical paper, and he congratulated him upon the way in which he had "kept off the grass": he had not said one word about price. Also, he had said nothing whatever about labour. The cost of labour was a very important factor in considering the possibility or otherwise of burning oil. Dealing with the table on page 237, he would like to know what were the conditions which made such a very great difference between the temperature of the escaping gases with coal burning and oil burning. When burning coal, the temperature of gases at base of stack was 615° F., and when burning oil it was 485° F. He would like to know what was the condition of cleanliness of the boiler and so on, because it was hardly to be expected that a boiler would evaporate 6,000 lbs. of water with coal and 13,800 lbs. of water with oil, and that the gases at the stack would be 120° lower with the oil than with the coal, unless something else had been altered. The author also mentioned the word "boilers," but evidently from the work done it was only one boiler. He also mentioned the curious fact that the temperature of the boiler house was 100° with coal firing and 75° to 85° with oil firing. How did that arise? It could not have been radiation from the stokers, because they only handled half a ton an hour, which was not very much. He had recently been across the Atlantic and back, travelling both ways in oil-fired ships. He had gone over in an 18-year old ship, the "Finland," and now that it had got oil firing one man attended to four boiler ends. The engine-room staff had been cut down by half, and, while the engine room men were as dirty and as sloppy as was to be generally expected, the boiler room men were infinitely cleaner and had little to do practically but to smoke cigarettes. He had asked what the comparative figures were, and had been informed that they were round about 3000 tons of oil to 4000 tons of coal for similar trips. They were burning on the White system, which was a low pressure system. A striking thing was that there was not an ounce of brick work in those furnaces, and that made a very great difference. If one shut down quickly radiant brick work would make steam for a long time after the oil had been shut off. Therefore, under some conditions it was very important that there should be no brick work in the furnace. In that boat the furnaces were worked with absolutely bare furnace tubes unprotected by brick work. He had come back on the "Olympic," which was also oil fired, but which had no hot air, and the difference between the products of combustion on the hot air system with the old "Finland" and the cold air system on the "Olympic" was very striking. It might be remembered that when the "Olympic" came round from Belfast a strike occurred. The owners wanted four boiler ends per man, but the Union wanted two boiler ends per man, and they arrived in the end at a compromise of three. But it was perfect child's play; if each man had five or six boilers to attend to it would not be hard work. He might mention one very important point in conclusion, which was to have no blank ends. If one was working in thick oils it was absolutely essential to circulate. He might remark that the author had said nothing whatever about the cost of his pumping circulation.

Mr. Charles R. Darling remarked that if oil was to be used for steam raising the greatest possible boiler efficiency should be aimed at, and he should like to ask the author whether he had had any experience of the use of oil firing in Bonecourt boilers. He thought that of all boilers the Bonecourt boiler, which normally was gas fired, had the highest efficiency —he thought it ran out to about 92%. He had been informed that trials had been made recently with oil firing which had been perfectly successful, and which had given an equally high efficiency, and if that was the case it would probably give some justification even to the most severe critics for the use of oil for steam raising. His next point was a metallurgical one. He would like to ask whether anybody had ever experimented on the production of an oxy-oil flame. There appeared to be no reason why, with oxy-oil flames, just as good a result should not be obtained on a large scale as was obtained with oxy-acetylene on a small scale. That would lead to a great many developments in the engineering world, and certainly in the metallurgical world. There were a great many new products and new processes

at present in existence which required a temperature of well over 2,000° C., which could not be obtained by any fuel which was fired in air. If oil could be used, either burned in enriched air or in pure oxygen, it might be possible to get on a fairly large scale very high temperatures, which would enable metals of very high melting points, to be smelted and dealt with and, in fact, permit of competition to some extent with the electric furnace.

THE CHAIRMAN said he was sure the audience must have been struck by the phase of the subject which dealt with the ease with which oil fuel could be used. That ease of use was accentuated when one remembered the intermittent way in which solid fuel had to be put on to the receptacle in which it was being used, as compared with the simplicity with which oil merely flowed from a tank through a pipe which could be regulated by the turning of a tap. Another point of great importance was the uniform temperatures which could be maintained. Uniform temperature in boiler practice indicated a uniform pressure. and the variation in the amount of oil could be easily regulated so as to get a uniform pressure. That was a very important factor in marine steam raising, but when one came to land processes in which the efficiency of the process depended upon uniform temperature, the value of a liquid fuel was obvious.

Again, the question of manual labour in connection with the use of fuel was one which acted very much to the advantage of the use of liquid fuel. After relating his experiences in the stokeholds of two ships burning coal and oil respectively, the Chairman continued that it was obvious, particularly for marine purposes, that, compared with coal, oil had the advantage every time, and even in certain classes of work on land, oil, or coal in a powdered form, or gas, must come into operation where a uniform and a careful regulation of temperature was needed. The general way in which coal was burnt was, fortunately, being very largely superseded by the greater quantity of oil that was coming into the world's markets, and that in itself would, he thought, drive coal users to utilise their coal to better advantage.

MR. BAILLIE, in the course of his reply, mentioned that the reason he used the French Navy figures for bringing up the subject of auxiliary oil firing was because the British Admiralty figures had not been available. He agreed with Dr. Ormandy that one ton of oil was approximately equal to two tons of coal. With regard to the question of the very much lower temperature obtained at the base of the stack in the test he quoted for land boilers, namely, 485° for oil and 615° for coal, that was due to the fact that a very much quicker combustion of the liquid fuel was obtained than was got with coal fuel. He had been surprised to hear from Mr. Patchell that the vessel on which he went across the Atlantic had used 300 tons of oil against 400 tons of coal, because in comparative tests taken on sister ships it had been found that for the same oil power, going the same routes, 1 lb. per one h.p. per hour had been used as against 1.75 of coal. With regard to Mr. Darling's remarks, he had a copy of the tests which had been carried out on the Bonecourt boiler at Leeds, about a week ago, and they came out at approximately 90% efficiency There had been one or two oversights in those tests, and he believed that an efficiency of 92 or 93% was being looked forward to. He had not any knowledge of any experiments having been carried out on oxy-oil flames, but he had been informed that natural gas when mixed with ogygen gave a greater temperature than the oxy-acetylene process.

CORRESPONDENCE.

COMPRESSED WHEAT.

Recent discussion of the new dangers foreseen to be probable in future wars has shown that our food supply will be menaced far more by aircraft than by the submarine, although both weapons are likely to be used.

There is one measure that might avert the risk of sudden famine through the stoppage of imports of corn, and assure for us a permanent reserve of wheat, immune from decay, inexpensive in storage, and probably safe from attack by vermin, and the present seems an appropriate moment to consider it in all its bearings.

That measure was submitted to the then Premier, Mr. Balfour, as far back as 1905, and was regarded both by him and Admiralty authorities as highly desirable and perfectly feasible, and as shown by its advocate, Lord Masham, was capable of application with so little expense, the cost being not more than 1s. a quarter, that no real obstacle could be found on that score.

His proposal was to crush or rough grind wheat, as if for cattle, kill germs and soften the grain by superheated steam, compress it into hard blocks by suitable apparatus, and store till wanted, when the crushing process would fit it for milling into flour.

The vast damage done to the Australian wheat crop held up by shipping difficulties last year would have been avoided had similar means been used to save it. Moreover, such a reserve as would thus be possible would entail no more loss of interest than is entailed by gold reserves, which also earn nothing, and it would also have a tendency to stabilise wheat prices by moderating the fluctuations due to crop failures or redundant harvests.

GEORGE SALE.

GENERAL NOTES.

ALUMINIUM IN GERMANY.—Great efforts were made during the war to put the manufacture of aluminium on a firm footing, in order to make Germany independent of foreign supplies. Plants were erected and the manufacture started at Horrem, Bitterfeld, and Rummelsburg, each factory having an output of 3,000 tons of aluminium per annum. In 1916 the Erftwerk A. G. was taken over by the Government and reorganised with a capital of 25,000,000 marks. The branch works of this company, in Grevenbroich (lower Rhine), have been fitted up to produce 12,000 tons of aluminium per annum.

GEOGRAPHICAL DISTRIBUTION OF BRITISH CAPITAL.—In 1914 the issues of new capital (excluding borrowings by the Government and certain other loans) in the United Kingdom amounted to £199,628,000, of which £40,707,000 was devoted to home purposes and £158,921,000 went to other countries. In 1920 the figures were as follows:—Total capital raised, £384,211,000; for home purposes, £330,980,000; for other countries, £53,231,000. The total of the new issues in January of the present year was £22,468,915, as compared with £42,446 in the corresponding period of 1920.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

MARCH 9 at 4.30 p.m.—WILLOUGHBY DEWAR, Hon. Secretary, Plumage Bill Group, "The Plumage Trade and the Destruction of Birds."

MARCH 16. — CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime." THE RIGHT HON. LORD JUSTICE ATKIN in the Chair.

APRIL 6.—PROFESSOR ARCHIBALD BARR, D.Sc., LL.D., M.Inst.C.E., "The Optophone."

APRIL 13.—PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Low Temperature Carbonisation and Smokeless Fuel."

INDIAN SECTION.

Fridays at 4.30 p.m.

APRIL 22.—LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

MAY 27.—WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

INDIAN AND COLONIAL SECTIONS.

(Joint Meeting.)

At 4.30 p.m.

TUESDAY, MAY 3.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

DR. C. M. WILSON, "Industrial Medicine."

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

CANTOR LECTURES.

MAJOR G. W. C. KAYE, D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures. March 7, 14 and 21.

Syllabus.

LECTURE I.—MARCH 7.—Introductory and Historical—The Nature of X-rays—The Ubiquity of X-rays—Their Generation—Various Types of X-ray Tubes and their Efficiency—Importance of Wave-Form of Exciting Potential.

LECTURE II.—MARCH 14.—High Potential Generators—Open and Closed Coil Transformers—Influence Machines—Homogeneous X-rays—X-ray Measurements—Intensity and Wave-Length—Characteristic X-rays—X-ray Spectroscopy.

LECTURE III.—MARCH 21.—Applications of X-rays to Various Branches of Industry—X-rays in Medicine—Future Developments and Improvements.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

MEETINGS FOR THE ENSUING WEEK.*

MONDAY, MARCH 7 .. University of London, at the Royal Society of Medicine, 1, Wimpole Street, W., 5 p.m. Dr. C. M. A. Kappers, "Structural Laws in the Central Nervous System; the Principles of Neurobiotaxis."

At the Institution of Civil Engineers, Great George Street, S.W., 5.30 p.m. Professor L. Luiggi, "Recent Engineering Works in Italy." (Lecture I.)

Post Office Electrical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m.

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev. H. C. White, "Public School Education."

Engineers, Cleveland Institution of, Corporation Road, Middlesborough, 6.30 p.m.

Royal Institution, Albemarle Street, W., 5 p.m. General Monthly Meeting.

Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. R. W. A. Brewer, "Some Modern Engineering Practice in America."

Chemical Industry, Society of (London Section) at the Chemical Society, Burlington House, W., 8 p.m. 1. Dr. J. C. Drummond, "Factors Influencing the Food Value of Lard and Lard Substitutes." 2. Dr. R. C. Farmer, "The Stability of Benzoyl Peroxide."

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m. Mr. A. B. D. Lang, "The Report from the Select Committee of the House of Commons on Business Premises."

Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. J. H. Driberg, "The Lango District, Uganda Protectorate."

Electrical Engineers, Institution of, at the South Wales Institute of Engineers, Cardiff, 7 p.m.

TUESDAY, MARCH 8 .. Transport, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m.

University of London, Royal School of Mines, South Kensington, S.W., 5 p.m. Professor W. W. Watts, "The Geological Work of Charles Lapworth" (Lecture I.).

Royal Institution, Albemarle Street, W., 3 p.m. Dr. A. Keith, "Darwin's Theory of Man's Origin in the Light of Present Day Evidence." (Lecture III.)

Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m.

Geological and Mining Society, Manchester, 4.0 p.m. Mr. J. Lomax, "The Various Forms of Pyrites in Coal. Their Probable Origin and Effects on being Exposed to Atmospheric Influences."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Annual General Meeting.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Professor F. G. Parsons, "The Head Form of the Long Barrow Race, with reference to the Modern Inhabitants of London."

Zoological Society, Regent's Park, N.W., 5.30 p.m.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Mr. J. W. McConnel, "Cotton Growing within the Empire."

Horticultural Society, Vincent Square, Westminster, S.W., 3 p.m.

Electrical Engineers, Institution of, Hote Metropole, Leeds, 7 p.m.

Electrical Engineers, Institution of, 17, Albert Square, Manchester, 7 p.m. Mr. A. B. Mallinson, "Electric Driving in the Paper Mill on Heat Economy Lines."

Electrical Engineers, Institution of, Princes Street, Station Hotel, Edinburgh, 7 p.m. Sir W. Noble, "The Long Distance Telephone System of the United Kingdom."

Automobile Engineers, Institution of, The Quadrant, Coventry, 7.15 p.m. Mr. G. M. Martineau, "Current Motor Cycle Frame and Chassis Design."

Metals, Institute of, 39, Elmbank Crescent, Glasgow, Annual General Meeting, 8 p.m., Address by Mr. J. Steven.

Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m. Mr. S. Leggett, "The Amritsar Hydro-Electric Irrigation Installation."

WEDNESDAY, MARCH 9 .. Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Rev. J. Steele, "The Animistic Basis of Eastern Religions."

Geological Society, Burlington House, W. 5.30 p.m. Mr. W. B. R. King, "Surface of the Marls of the Middle Chalk in the Somme Valley and the neighbouring parts of Northern France, and the effect on the Hydrology." Miss G. L. Elles, "The Bala Country: its Structure and Rock-Succession."

Metals, Institute of, Institution of Mechanical Engineers, Storey's Gate, S.W. 1, 10.30 a.m. 1. Professor H. C. H. Carpenter and Miss C. F. Elam, "Stages in the Re-Crystallisation of Aluminium Sheet on Heating, with a Note on the Birth of Crystals in Strained Metals and Alloys." 2. Mr. P. H. Brace, "Some Notes on Calcium." 2.30 p.m. 1. Professor C. A. Edwards and A. M. Herbert, "Plastic Deformation of some Copper Alloys at Elevated Temperatures." 2. Messrs. H. Moore and S. Beckinsale, "The Action of Reducing Gases on Heated Copper."

Literature, Royal Society of, 2, Bloomsbury Square, W.C. 1., 5.15 p.m. Professor Walter de la Mare, "Imaginative Prose."

THURSDAY, MARCH 10 .. Fine Art Trade Guild, at the ROYAL SOCIETY OF ARTS John Street, Adelphi, W.C., 7.30 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, W. 8.30 p.m.

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Dr. H. Rees, "Chinese Fiction."

Metals, Institute of, at Institution of Mechanical Engineers, Storey's Gate, S.W. 1., 10.30 a.m. Annual General Meeting (continued). 1. Messrs H. Moore, S. Beckinsale and C. E. Mallinson, "The Season Cracking of Brass and other Copper Alloys." 2. Dr. J. L. Haughton, "The Constitution of the Alloys of Copper with Tin." Parts III. and IV.

Royal Institution, Albemarle Street W., 3 p.m. Dr. G. C. Simpson, "The Meteorology of the Antarctic." (Lecture I.)

Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m. 1. Professor H. F. Newall "The Story of a New Star." 2. Mr. T. F. Connolly, "Note on a Handy Form of Measuring Microscope."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Professor E. Wilson, "Feebly Magnetic Materials." Lecture III. Practical Applications.

Historical Society, 22, Russell Square, W.C., 5 p.m. Mr. A. H. Thomas, "Illustrations of the Mediæval History of London, from the Guildhall Records."

Mathematical Society, Burlington House, W., 5 p.m.

FRIDAY, MARCH 11 .. London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4 p.m. Annual Meeting. 4.30 p.m. Mr. I. G. Gibbon, "Zoning and Town Planning."

Royal Institution, Albemarle Street, W., 9 p.m. Dr. J. Freeman, "Medical Idiosyncracies."

Civil Engineers, Institution of, Great George Street, S.W., 8 p.m. (Students' Meeting.)

Electrical Engineers, Institution of, King's College, Strand, W.C. 2., 6.30 p.m. (Students' Meeting.) Mr. J. A. Broughall, "Some Recent Developments in Converting Machinery for Small Substations.

Engineers and Shipbuilders, North-East Coast Institution of, at Literary and Philosophical Society, Newcastle-upon-Tyne, 7.30 p.m. Mr. A. L. Ayre, "Organisation for Ship Production."

Astronomical Society, Burlington House, 5 p.m.

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

SATURDAY MARCH 12 .. Engineers and Shipbuilders, North-East Coast Institution of, Newcastle-upon-Tyne, 6.30 p.m. (Graduate Section). Professor G. Thompson, "Theory of Probability."

Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Electricity and Matter." (Lecture II.)

Chromatics, International College of, Caxton Hall, Westminster, S.W., 3.15 p.m. Professor H. M. Léon, "The Story of the Discovery of Colour Blindness."

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 14th, at 8 p.m. (Cantor Lecture.) MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." (Lecture II.)

WEDNESDAY, MARCH 16th, at 8 p.m. (Ordinary Meeting.) CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime." The Right Hon Lord Justice Atkin in the chair.

CANTOR LECTURE.

On Monday evening, March 7th, MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc., delivered the first of his course of lectures on "X-Rays and their Industrial Applications."

The lectures will be published in the *Journal* during the summer recess.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 2nd, 1921; LORD HENRY CAVENDISH BENTINCK, M.P., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Adams, Charles Hubert, B.Sc., A.M.I.A.E., Shinfield, Berkshire.
Gaul, James, Jamaica, B.W. Indies.
Lynch, Hon. James Challenor, O.B.E., LL.M., Barbados, B.W. Indies.
Macnab, Henry Edwin, London.
Marreco, Geoffrey Algernon Freire, Woking, Surrey.
Phillips, Edward George, London.

The following Candidates were balloted for and duly elected Fellows of the Society —

Dyson, William, Rotherham.
Garrett, J. D., London.
Hart, T. C., B.A., Dominica, B.W.I.

A paper on "The Re-Education of the Disabled" was read by Captain J. Manclark Hollis, Secretary to the Village Centres Council.

The paper and discussion will be published in a subsequent number of the *Journal*.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1921 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 26th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce, and has been awarded as follows in previous years:—

1864, Sir Rowland Hill, K.C.B., F.R.S.
1865, His Imperial Majesty, Napoleon III.
1866, Michael Faraday, D.C.L., F.R.S.
1867, Sir W. Fothergill Cooke and Sir Charles Wheatstone, F.R.S.
1868, Sir Joseph Whitworth, LL.D., F.R.S.
1869, Baron Justus von Liebig.
1870, Vicomte Ferdinand de Lesseps, Hon. G.C.S.I.
1871, Sir Henry Cole, K.C.B.
1872, Sir Henry Bessemer, F.R.S.
1873, Michel Eugène Chevreul.
1874, Sir C. W. Siemens, D.C.L., F.R.S.
1875, Michel Chevalier.
1876, Sir George B. Airy, K.C.B., F.R.S.
1877, Jean Baptiste Dumas.
1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S.
1879, Sir William Thomson (afterwards Lord Kelvin), O.M., LL.D., D.C.L., F.R.S.
1880, James Prescott Joule, LL.D., D.C.L., F.R.S.
1881, Professor August Wilhelm Hofmann, M.D., LL.D., F.R.S.
1882, Louis Pasteur.
1883, Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1884, Captain James Buchanan Eads.
1885, Sir Henry Doulton.

1886, Samuel Cunliffe Lister (afterwards Lord Masham).
1887, HER MAJESTY QUEEN VICTORIA.
1888, Professor Hermann Louis Helmholtz.
1889, John Percy, LL.D., F.R.S.
1890, Sir William Henry Perkin, F.R.S.
1891, Sir Frederick Abel, Bt., G.C.V.O., K.C.B., D.C.L., D.Sc., F.R.S.
1892, Thomas Alva Edison.
1893, Sir John Bennet Lawes, Bt., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.
1894, Sir Joseph (afterwards Lord) Lister, F.R.S.
1895, Sir Isaac Lowthian Bell, Bt., F.R.S.
1896, Professor David Edward Hughes, F.R.S.
1897, George James Symons, F.R.S.
1898, Professor Robert Wilhelm Bunsen, M.D.
1899, Sir William Crookes, O.M., F.R.S.
1900, Henry Wilde, F.R.S.
1901, HIS MAJESTY KING EDWARD VII.
1902, Professor Alexander Graham Bell.
1903, Sir Charles Augustus Hartley, K.C.M.G.
1904, Walter Crane.
1905, Lord Rayleigh, O.M., D.C.L., Sc.D., F.R.S.
1906, Sir Joseph Wilson Swan, M.A., D.Sc., F.R.S.
1907, The Earl of Cromer, O.M., G.C.B., G.C.M.G., K.C.S.I., C.I.E.
1908, Sir James Dewar, M.A., D.Sc., LL.D., F.R.S.
1909, Sir Andrew Noble, K.C.B., D.Sc., D.C.L., F.R.S.
1910, Madame Curie.
1911, The Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., F.R.S.
1912, The Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., G.C.V.O., LL.D., D.C.L., F.R.S.
1913, HIS MAJESTY KING GEORGE V.
1914, Chevalier Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.
1915, Sir Joseph John Thomson, O.M., D.Sc., LL.D., F.R.S.
1916, Professor Elias Metchnikoff.
1917, Orville Wright.
1918, Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S.
1919, Sir Oliver Joseph Lodge, D.Sc., LL.D., F.R.S.
1920, Professor Albert Abraham Michelson, For. Member, R.S.

CASES FOR JOURNALS.

At the request of several Fellows of the Society, cases have been made for keeping the current numbers of the *Journal*. They are in red buckram, and will hold the issue, for a complete year. They may be obtained post free, for 7*s*. 6*d*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

EXTRA MEETING.

TUESDAY, FEBRUARY 8TH, 1921.

MR. G. J. WARDLE, C.H., late Parliamentary Secretary, Ministry of Labour, in the Chair.

The following paper was read:—

SOME OF THE PROBLEMS OF UNEMPLOYMENT.

By ED. C. DE SEGUNDO, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E.

The world is confronted to-day with many problems of unprecedented complexity, and perhaps the one calling most insistently for solution is the problem of unemployment, not only because of the suffering attendant upon abnormal unemployment, but because this indicates a set-back in our recovery from the effects of the War, and also because there seems little doubt that the extremists, under the guise of advancing the interests of labour, are exploiting unemployment for the purpose of fostering their revolutionary campaign. It is perhaps needless to say that the true labour movement is *not* revolutionary.

The problem of unemployment did not arise yesterday nor yet the day before. Twenty-three centuries before Christ the Assyrian Hammurabi wrestled with the self-same industrial problems we are experiencing to-day, and drew up a code regulating the relations between master and man, and fixing a minimum wage for artisans of all classes. Clearly, Hammurabi did not permanently solve the problem, and humanity has gone on ever since unsuccessfully trying to substitute rules and regulations, Acts of Parliament, and "isms" and "ologies" galore for the only real panacea for social ills—the observance of the golden rule which Emerson merely paraphrased when he wrote: "Every man takes care that his neighbour shall not cheat him. But a day comes when he begins to take care that he does not cheat his neighbour. Then all goes well." If masters and men took care not to cheat each other, the occupation of the agitator would be gone. And yet, this is not the whole story. A difficulty—in some cases an insuperable difficulty—arises when the increase of the population outstrips the means of subsistence. This brings us into deep waters, which I dare not even attempt to plumb to-night. But

this aspect of the problem must be faced, and that in the not far-distant future.

Introductory Remarks.

The world situation to-day in regard to employment is a gigantic paradox. There can be no question whatsoever of the immense amount of work waiting to be done, work of reparation of property, work of rehabilitation of commercial and industrial relations, and work of reorganising the destroyed and dislocated means of transport and communication between nations. Nevertheless, unemployment threatens to increase, not only in Great Britain, but throughout the whole world, except in Germany.* This War has brought to light in a way that nothing else could have done, how completely interdependent individuals, communities and nations have become. No country in the civilised world can to-day be said to be self-sufficing or self-supporting. Every country is vitally in need of commodities it cannot produce, which it must, therefore, obtain from beyond the confines of its own territory. For a couple of generations during the last century Great Britain enjoyed an unexampled period of prosperity, and for a time became the strong-box of Europe and the workshop of the world, owing chiefly to its easily and cheaply worked supplies of coal and iron ore. This state of affairs has long since ceased to exist, although London continued to be the financial centre of the world, and Great Britain became, so to speak, the world's exchange, for England was a creditor country up to the outbreak of war, while practically every other country was debtor to England. But this state of affairs also is a thing of the past. The financial strain of conducting our military and naval operations and of financing some of our Allies has necessitated the realisation of a large proportion of our investments abroad, in addition to which we have contracted a considerable debt to the United States.

During the War commodities had to be produced irrespective of cost. The Allies won the War, and thereupon a large number of us thought that there would be an immediate commencement of a period of great business activity. Those who had been able to command practically any price for their services during the War expected to continue to receive remuneration on a similar scale. This was not unnatural, it was merely human nature—but it was not common-sense. In view of the economic condition to which the Central Empires had reduced themselves, the immediate payment of an appropriate indemnity *in cash* was impossible. It is strange how wide-spread is the idea that *any* amount of cash can be got together if only sufficient pressure be applied. Few know that in pre-war days the total amount of bullion in the world was insufficient to liquidate more than a mere fraction of the world's indebtedness; the proportion to-day would be microscopic. International financial relations are based upon *credit*, and a nation's credit is a function of its developed and undeveloped natural resources; of its gold reserve; and of its foreign trade balance.

Misuse of the Terms "Capital" and "Labour."

Most of us still consider "capital" to be synonymous with cash or its equivalent, and "labour" as applying only to manual work, and assume that there is a fundamental antagonism between them. A right perception of the meaning of capital and labour reveals the fact that neither is, in itself, capable of achieving any useful purpose, and that what people *really* mean when making use of these terms is the *employment* of capital or the *employment* of labour. Thus the element of directive ability is unconsciously implied just as in speaking of a "force," the existence of somebody or something that gives the force magnitude and direction is necessarily involved, although this is not always realised. Capital and labour are, in themselves, inert (though necessary) factors in the production of wealth and the vitalising factor is directive ability. This simple truth was admirably exemplified recently, when the workmen seized the factories of the Fiat Company in Italy, and a few weeks afterwards had to beg the so-called "capitalist" element to take charge again.

"Capital" and "Labour" are, in last analysis, not *commodities*, but are the outcome of different manifestations of the intellectual faculties directed by the will. Directive ability, whether applied to one's own form of activity or to that of some other person, is a form of capital. The humblest labourer who merely carries out instructions must use his brains, and, in this sense, belongs to what is so loosely

* See the General Report of the Industrial and Economic Situation in Germany, 1921 [Cmd 1114], p. 62.

termed the "capitalist" class, as much as the man who controls the largest amount of cash or credit.

The mere possession of cash does not bring with it the ability usefully to employ the cash. We all know the adage "a fool and his money are soon parted," and also the North Country aphorism, "It only takes three generations from clogs to clogs."

The Proximate Causes of Present-Day Unemployment.

The proximate cause of unemployment in this country to-day is unquestionably the simple fact that the price at which commodities can be remuneratively sold has risen above the purchasing power of a large number of consumers. This has come about owing to the neglect on the part of the producer class of a rudimentary principle of economics, namely, that there is a limiting relation between the rate of earning of the producer and that of the purchaser, and that there is a limit to the extent to which the temporary necessities of others can be remuneratively exploited. For every seller there must be a buyer; there is no incentive to produce if no remunerative market exist for the product. Thus increase of production will not, of itself, avail effectively to reduce unemployment or to relieve our financial embarrassments, unless the commodities produced respond to the demand and be offered at a price that will successfully compete with that at which other producers offer them.

This applies not only to our domestic trade (whereby the importation from abroad of articles we can ourselves produce can be reduced and the adverse trade balance diminished), but to our export trade, which helps to pay for those commodities we need, but cannot ourselves produce.

To take a concrete example: Great Britain has to import a large quantity of foodstuffs from foreign countries, but it can only continue to do so as long as it produces and ships to these countries commodities such countries desire at a price they are willing to pay. If foreign countries cease to desire what Great Britain makes, or if they can obtain what they desire more cheaply elsewhere, then Great Britain will starve, and no juggling with the exchanges or other artificial expedient the wit of man may devise will alter this. There is no possible escape from the consequences attending an increase of the population beyond the means of subsistence. The maintenance of a working relation between these two things is a condition *sine quâ non* of our persistence as a nation.

The consumer must also be a producer and must find a market for his products, otherwise his power to consume will wane. The productivity of Russia, of Austria, of Hungary, and of other European countries is greatly diminished; their power to purchase is correspondingly reduced; they cannot buy the goods they would like to have from us (or from others); we consequently suffer from the absence of the markets which existed before the War for certain of our products. Money must be earned before it can be spent in wages or anything else. Most of us, from Ministers at the Treasury to Labour Leaders, seem to ignore this simple fact. On the one hand, labour has abused the power conferred by the organisation it has legitimately brought about, and in regard to wage increase has held the unorganised portion of the community to ransom time and again. On the other hand, the Government has abused the authority vested in it by the country, and has launched out into extravagant projects—no doubt with the most laudable intentions—without appearing to be concerned whether or not the country is able to foot the bill.

Both parties have exhibited a lack of a proper sense of proportion.

Both parties have relied upon the defenceless position of the unorganised taxpayers.

But *naturam expellas furca, tamen usque recurret*. The continued drawing of water from a cistern at a greater rate than that at which the supply pipe delivers, naturally results in the exhaustion of the contents of the cistern. Moreover, the "factor of dispensability" has come into operation; the vast majority of us are restricting our commitments to bare necessities; demand is lowered in an increasing proportion; manufacturers cannot dispose of their products except at a loss; production is curtailed, or stopped; and workers of all grades are thrown out of employment.

One of the governing factors in the present industrial situation in this country is the effect of the Excess Profits Duty.

As a war-time measure, when owing to the impossibility of accurately estimating costs and values, gigantic profits were being made by Government-controlled establishments financed, very often, with Govern-

ment money, it served the useful purpose of a rough and ready means of adjusting, in some degree, the great disproportion between real cost of production and price paid by the country for the necessaries of war. The continuance of this tax was unsound commercially, shortsighted financially, and simply disastrous industrially speaking. In 1919 the tax was reduced and its abolition in 1920 was confidently anticipated, instead of which it was increased from 40% to 60%, in spite of the most strenuous endeavours on the part of eminent and respected leaders of industry to convince the Government of its error. The commercial risk of carrying on business was immeasurably increased. All plans for the extension of plant and machinery, all schemes for expansion of business relationships, all initiative and enterprise received a death-blow.

The sequence of events has been but the natural operation of cause and effect. The return on capital invested in industrial undertakings became entirely problematic—the only certainty being that it would be reduced. The uncertainty respecting the demands of organised labour and the seemingly extravagant expenditure by the Government accentuated the already sufficiently precarious position of the investor. Many thought it better to have their money on deposit at their bank than to leave it invested in shares of public companies which were an easy prey to the predatory attacks of ill-considered financial legislation. In addition there has been much forced liquidation to provide the wherewithal to pay income tax, and the resulting depreciation in the values of Stock Exchange securities since January, 1920, is calculated to have been at one time about £500,000,000. Owing to the unstable economic position, and to the increasing lack of confidence in the power of the Government to deal with the situation, the savings of the thrifty, which under normal conditions form the main source of financial support for the development of new industries or for the expansion of existing industries, are not available for these purposes to-day, and one of the chief factors in the stabilization of employment is, therefore, absent. Judging by the aggregate Bank deposits in the United Kingdom, these accumulated savings must amount to-day to a very large sum indeed. The withdrawal of credit from trade and industry; the high Bank rate; the unprecedentedly severe fall in the values of commodities during the last months of 1920 and the crushing burden of present-day taxation, are strangling industrial activity and are conducing, as a natural result, to the increase of unemployment, which—leaving out the sentimental aspect—is of the gravest import to the economic position of the country.

It is becoming more and more evident that the net amount the Excess Profit Duty will yield will not be anything like the sum anticipated. Owing to the shrinkage of trade, the Government will have to refund large amounts during the next two years, and thus not only has the Excess Profits Duty stricken unto death the goose that lays the golden eggs, but a considerable proportion of the golden eggs will become unavailable for the purposes for which the goose was killed.

Four days ago the Chancellor of the Exchequer, impelled by the extreme gravity of the situation, announced that the provisions of this year's Budget would include the abolition of the Excess Profits Duty.

If this announcement had been made a few months ago, a good deal of the unemployment existing to-day could probably have been avoided.

Attitude of Labour.

A word now as to the attitude adopted by "Labour." My experience of the British working man coincides with that expressed not so long ago by Sir Alfred Yarrow. He said that the British working man, speaking generally, had a fund of sound common-sense and had his heart in the right place, but he had one defect, namely, that he could not see far enough ahead. With all respect to our friends the Labour Leaders, can *they* see much further ahead than the average working man? and if they do, can they carry their men with them? Now, whatever may be the nature of the "secret diplomatic action" among Labour Leaders, is not the attitude of some of them—so far as the unorganised portion of the community is concerned—very much of this order: "We want so and so, and we are going to have it, and if you don't give it to us we will stop your railways, and your coal, and your food." Does this encourage the brains of the community to undertake the organisation of new enterprises tending to create further employment?

Lightning strikes and other forms of "direct action" are not exactly calculated to promote friendly relations between employer and employed, or to encourage the initiation of new undertakings which, perforce, involve a high degree of risk until proved to be commercially successful. I have looked into many schemes for promoting the interests of the "working classes," but I do not recollect a single instance in which any account is taken of the risks run by those who devote their brains and their money to the *development* of existing industries, or to the *creation* of new industries, upon both of which forms of activity an increase in the employment of the workers depends. During the period (and it may be years) required to work out some new invention, or commercially to test the efficiency of some new process, as applied to an existing industry, the workers receive their wages regularly and have no responsibilities, whereas those who supply the money during the experimental period and those who have to solve the technical and commercial problems involved, bear the whole risk and the whole burden of worry and anxiety. In the case of failure, a dead loss is incurred; in the case of partial success, a but meagre return is yielded; in the case of complete success, surely those who have taken the entire risk are entitled, in common justice, to a greater share of the proceeds than those who have borne neither risk nor responsibility.

Only those who have had personal experience of what is involved in bringing a new idea to fruition, in the teeth of opposition, with faint support, hampered and discouraged by the deep-rooted prejudice almost invariably exhibited against "anything new," can estimate at its true value the work of the pioneer in any branch of science or industry. Under subsisting conditions of taxation, and in view of the wholly indeterminable character of the demands of organised labour, there is no inducement whatever to do more than to endeavour to keep one's business alive and avoid the Bankruptcy Court.

It is not often realised that a tax of 6s. in the £ on *earned* income is virtually the equivalent of *two days' forced labour per week*.

The avowed object of many of the Trade Unions seems to be *not* to stimulate a desire to excel among the members, but, on the contrary, to discourage any member from working more efficiently than the least efficient of the members, to the end that the greatest number of men may have to be employed to do a given amount of work. Again, we have the natural sequence of cause and effect, the performance per man steadily diminishes, both as regards quality and quantity. Wages remaining at the same level, the value yielded per unit of wages sinks, cost of production rises, competition in the international market becomes more and more difficult, and it does not require a Solomon to foresee the inevitable result—the ruin of our foreign trade, the decline of trade and industry and eventual national bankruptcy.

Encouragement of Initiative in Industry and Protection of Key Industries.

History teaches us that there is the analogy of birth, adolescence, and decay in industrial processes.

As time goes on, conditions alter and existing processes become obsolete, and in proportion to the extent we keep abreast of the times so shall we maintain our position in the commercial world, and maintain and increase the occasions for the employment of labour. A suitable measure of relief from taxation in respect of expenditure on scientific and experimental research would greatly stimulate effort in the direction of improving existing methods and of turning to account the by-products and waste products of industry. This could not but benefit the community at large, and, moreover, the adoption of measures to this end would only be on a par with the grant to an inventor of the monopoly of his invention for a period of years in order to afford a proper opportunity for the establishment of such invention on a firm commercial footing.

Any industry adjudged to be an essential (or key) industry should—it would appear—be *permanently* protected from attack by "dumping" or other form of foreign competition.

Experiments in Social Reform.

These are, no doubt, very interesting times, historically speaking, but the making of history is not always an easy or a pleasant process. We are making gigantic experiments on an unprecedented scale in what is termed "social reform." That social

conditions need reform I do not question for one moment. They always have, and they always will, because of the imperfections of human nature. Socialism is a beautiful ideal, a consummation devoutly to be hoped, but the argument for Socialism is a *petitio principii*; it presupposes the existence of that which it seeks to bring about, because true socialism necessarily involves perfect humanity, and if humanity were perfect there would be no call for socialism.

History records many attempts to put socialism into practice. All have failed. The explanation usually given is that they were carried out on too small a scale. Surely the trial has been made on a sufficiently large scale in Russia, and what has been the result? Absolute and complete failure except from the point of view of those who have been astute enough to secure for themselves the power of "directing" the distribution of wealth.

The fact that men *do* rise, and have risen throughout all generations, from poverty to affluence, from obscure to leading positions in every branch of art, science, industry and commerce, indicates clearly enough that our subsisting social system is no *inherent* bar to progress and the achievement of success by those born in humble circumstances.

The exercise of intelligence, the ability to form a reasoned judgment, the power to organise, perseverance, prudence, and a hundred other attributes without which our social and industrial life would not subsist for one moment, are incapable of being weighed or measured, or valued in money; nor can they be coerced by any physical agency. They are possessed in widely differing degrees by members of all classes. There is good and evil in every one of us, and no class can claim pre-eminence in brains or virtue. There is a natural—and inevitable—tendency for human beings to become automatically segregated into classes irrespective of the accidents of birth or convention, just as eggs are classified irrespective of the breed of hens that laid them. The "class war," as exploited by certain propagandists, is not only a pernicious and mischievous one, it is also untenable. The members of the so-called "classes" are in a constant state of flux. A bookbinder's assistant becomes a leading light in the scientific world, a railway porter becomes a Minister of the Crown, a peer's son becomes a dock labourer and—ethically speaking—the peer's son may rise and the railway porter fall in the process.

A little reflection should convince us that all men are not equal, physically, mentally, or constitutionally, and that there are no such things as "natural rights."* A member of a civilised community only acquires rights by earning them. To-day we hear too much of rights and privileges and too little of the observance of concomitant duties and responsibilities. Many of us think that it is of the essence of business to obtain something for less than its value—for nothing if possible.

Such men respect the conditions of legal liability and of limited liability, but are not over-much concerned with the unwritten obligations of moral liability, although, paradoxically enough, few of them would hesitate to endorse the opening words of the recent resolution of the Association of British Chambers of Commerce in connection with the resumption of trade with Russia, namely, that the maintenance of good faith and the sanctity of contract are the bases of all human intercourse, whether commercial, political, or social.

Education and the Observance of the Moral Law.

In ultimate analysis, the only thing that will keep us from social disintegration, is the more rigid observance of the moral law. In February, 1919, Mr. W. L. Hichens concluded an interesting paper on "The Wage Problem in Industry" with these words:—"Failure to solve our industrial problems implies moral failure on our part, and it is well to recognise it and to realise that the most profound and exhaustive research will never find a substitute for the moral code which is the mainspring of all human societies."

Lord Askwith, in his profoundly interesting work, "Industrial Problems and Disputes," says:—"If the orderly advance of peaceful development is to be obtained, in place of the surging storms of hatred and strife, there must be more knowledge, so that men should not blindly follow guides who may be blind. . . There must be efforts to improve the comfort of the

*The most completely shattering exposure of the doctrines of Rousseau and of men of his school of thought of which I am aware, is to be found in Huxley's essay "On the natural inequality of man" and on "Natural and Political Rights."

workshop and its surroundings, reduce the monotony of work, and by all possible means obviate the fear of unemployment. . . There must be the desire of common interest partly by the touch of human and personal sympathy, partly by the joint interest of material gain, with the ideal of joint service. It is the *spirit*, not *paper systems*, which alone can prevent war and reduce the reasons for industrial strife.''

But the inculcation of this principle does not occupy a prominent place in our educational system, which is concerned too much with *books* and too little with *things*.

One of the results of our much vaunted— and expensive—system of education has been to bring into existence a large class who have learnt to reason, but have not been taught how to reason correctly.

''This belief in the moralising effects of intellectual culture, flatly contradicted by facts,'' Herbert Spencer told us in 1875, is absurd *a priori*. . . . ''One who should by lessons in Latin hope to give a knowledge of geometry, would be thought fit for an asylum, and yet he would be scarcely more irrational than are those who by discipline of the intellectual faculties expect to produce better feelings.''

The dire consequences of confining education to the development of the rational faculties are shown in the utter preversion of the moral sense of Germany to-day. ''Education,'' said Mr. Ellis Barker, in the ''Nineteenth Century'' three years ago when referring to the Prussian system of education, ''far from enlightening the German nation, has blinded, debased, and dehumanized it.'' Forty-five years ago Cardinal Manning uttered words respecting the future of Germany, which the event has shown to have been truly prophetic. He said:— ''A fatal extinction of supernatural light, the aberration of false philosophy, the inflation of false science and the pride of unbelief, are preparing Germany for an overthrow or for suicide.''

Would it not be the part of wisdom for us to take warning?

The Importance of the Study of Economics.

Economics has been called ''the dismal science.'' Dismal or not, it is a science with which we shall have to occupy ourselves in the future to a vastly greater extent than we have done in the past. We must take the growth and development of other countries into practical account. It cannot be too insistently dinned into the ears of every man, woman and child in Great Britain that we are dependent upon foreign countries for the greater part of the necessaries of life, that we can only continue to obtain these necessaries of life by giving these countries at least the equivalent in value of what we get from them and that this must be achieved by appropriate industrial effort and by the maintenance of an efficient land and sea transport system. A few days ago, Mr. Arthur W. Kiddy, in an illuminating lecture on ''Our foreign trade in relation to the position of the Exchanges,'' pointed out that ''although for general convenience the system of barter between countries has long since been abandoned, and settlements are effected on a monetary basis, the *principle* of barter remains to-day.'' The failure on the part of employers and employed alike—speaking generally—to *realise* this fact is the only reasonable explanation of the continuance of the internecine strife which has characterised the history of our industry and trade during the last few years. Workers and employers are both to blame, and I am not going to attempt to apportion the blame, but I am going to express the unshakable conviction that nothing of any permanent value will be achieved by violence on either side; that it is *reform* we need, not *revolution*, and that such reform can only be prosecuted with any hope of success by masters and men getting to know each other better, by each studying the necessities and difficulties of the other, and by replacing the policy of ''get—or if need be, *grab*'' by ''help— and if need be, *give*.'' Differences between masters and men can only be satisfactorily settled by discussion between representatives of each side who are sufficiently acquainted with the needs of the other and any endeavours to deal with such questions by academic measures or legislative enactments are foredoomed to failure. I consider myself fortunate in having as Chairman to-night Mr. George Wardle, whose services, as Parliamentary Secretary of the Ministry of Labour, in the cause of industrial peace need no mention from me. Mr. Wardle is also Vice-President of the Industrial League and Council, an association formed in 1915, with the object of bringing master and man into more intimate relationship, and I hope

he will give us some details of this admirable organisation, which has already rendered yeoman service alike to employers and to employed.

ORGANISATION OF AN INDUSTRIAL ARMY.

Assuming that the moral law be recognised alike by masters and men, I cannot see that we have any alternative but to consider that our working classes are just as much a necessary factor in the life of our social organism as the air we breathe is in the life of the individual. Provided every worker, be it one who uses his head or one who uses his hands, recognises that firstly he must qualify as a citizen; secondly, that he is only entitled to remuneration in proportion to the services he renders, and, thirdly, that the scale of remuneration is to be based upon the character as well as the extent of his service, a strong analogy seems to exist between such workers as a body, in relation to the maintenance of our industry and commerce, and our Army and Navy in relation to the maintenance of our independent national existence. Our military and naval forces are not always actively engaged; our police are not always arresting delinquents, nor are our firemen continuously putting out fires, but when necessity calls, we expect them to be ready for immediate service. Similarly, in times of active demand for the products of industry more workers will be required than in times when the demand is low. During the period of slack demand the country should recognise that the workers not required for the time being should be maintained and kept occupied in such wise that their efficiency is not impaired so that they may be available for active service in time of need. The country should be prepared to look upon this aggregation of workers as its "industrial army" and to provide for the proper maintenance of any portion of this army during the period when it is not on active service, the means for so doing being provided by some form of insurance to which the Government, workers, and employers should contribute in proportions to be determined—appropriate measures being adopted—it goes without saying—to minimise the abuse of this principle. Further, this industrial army should be drawn from the ranks of *British* working men who have qualified, and remain qualified, in the manner above indicated, and should not be open to alien hordes who have no inherent claim upon Great Britain.

While giving the Labour leaders every credit for good intention and while not underrating the value and importance of constitutionally conducted Trade Unions, there is no question whatsoever that a standard of efficiency, ability and moral character should be fixed by the Trades Union authorities as a condition precedent to membership, and that it should be the responsible duty of the officials of the Union to see that every labourer *is* worthy of the hire they insist upon his receiving, and that his liberty of action as regards the hours he works or the character of the work he does is not interfered with.

Similarly, the attainment of a standard of efficiency, ability and moral character should be a condition precedent to the appointment of any man to any administrative or executive post in industry.

We stand to-day in deadlier peril of our national existence than at any time during the war. We knew *then* what we were fighting against; to-day we are assailed by insidious foes from within, as well as from without; traitors to all that stands for right and reason, enemies alike to capital and labour, because they live among us, take our pay, and yet do not hesitate to advocate—indeed openly advocate—"putting sand in the boilers of locomotive engines, destroying the vital parts, of machines or breaking looms" (I have quoted from a recently-published book entitled "Direct Action"), in attaining their sinister ends. It is needless to say that all respectable members of the labour movement deprecate such methods, and condemn and disown those who resort to them, and it must not be forgotten that Bolshevism was first encouraged and fostered by Germany. We have no natural defences against the perversion of the minds of our less intellectually endowed brethren by the cunningly devised sophistries of such enemies. We can only strain every nerve to expose the real intent of such propagandists and arrest the division of our house against itself by dispersing the atmosphere of mistrust between employer and employed; by actively condemning, and wherever possible suitably punishing, the abuse of confidence in trade and business; by enforcing more strictly the provisions of the law against perjury; and generally by spreading and fostering in the greatest possible measure, and by all available

means, the dissemination of sound healthy moral principle, particularly in the minds of the rising generation.

Summary.

The views expressed in the foregoing lines, may be summarised as follows:—

That the interdependence of all civilised countries renders it impossible to leave out of consideration trade relations with foreign countries in working out any scheme for the mitigation of unemployment in Great Britain.

That increased production will not cause any relief unless commodities are produced of a character and at a price that will—

(a) Reduce our imports from foreign countries.

(b) Enable us successfully to compete with other producers in foreign markets.

That the maintenance of a working relation between the population of any country and the means of subsistence in that country is essential to the persistence of that country's national existence.

That rights and privileges are not natural endowments, but are rightfully enjoyed only in consideration of the discharge of duties and responsibilities.

That "Capital" and "Labour" *in themselves* accomplish nothing, and that it is only by the application of directive ability that they become factors in production.

That the closest co-operation is essential between those who direct the employment of capital and of labour, and those who carry such directions into effect, in order to ensure the re-establishment of our foreign trade, without which our position in the commercial world would be irretrievably lost.

That the home demand be supplied, as far as practicable, by the product of home industry, to the end that the proportion of such commodities now imported from abroad be reduced as much as possible.

That every useful means be adopted, by individual effort and by active propaganda, to ameliorate the relations between employer and employed, and to instruct both classes in the essentials of economics.

That the powers of the Government to involve the country in heavy annual expenditure, without adequate prior consideration, be restricted.

That the observance of the moral law be stimulated by education and by more rigidly enforcing the provisions of the law against breaches thereof.

That proper encouragement be given by suitable legislation to the initiation and development of new industries—particularly those relating to the utilisation of waste or of by-products.

That a new industry, if deemed worthy of support, be protected from foreign competition for a suitable period (just as an inventor whose ideas are deemed worthy of a patent protection is given a monopoly of his invention for a term of years), to the end that a proper opportunity be afforded for such new industry to become strong enough to hold its own against foreign competition.

That all industries adjudged to be essential (or key) industries, be permanently protected in a suitable manner.

That some form of insurance against unemployment—at least, in essential (or key) industries—be adopted, to which workers, employers and the country shall contribute in proportions to be determined, to the end that trade and industry be maintained at the highest possible efficiency.

That such workers, in the aggregate, be regarded as our "industrial army," the size of such "army" being determined by joint action between Trade Unions and, say, the Federation of British Industries, or other organisation representing the employers' interests.

That the attainment and maintenance of a standard of character, skill and efficiency, be a condition of service in the "industrial army."

That undesirable aliens be unconditionally excluded from the "industrial army," and that in all cases preference be given to British-born men and women; and that the provisions of the Aliens' Restriction Bill be rigidly enforced.

That neither strike nor lock-out be resorted to in the event of any disagreement or dispute. All strikes and lock-outs come to an end sooner or later, and nothing is gained, but much is lost, by the cessation of work during the period of negotiations.

DISCUSSION.

The Chairman (Mr. George James Wardle, C.H.), in opening the discussion, said that if he had any single complaint to make against the paper, it was that the problems dealing with unemployment had been very lightly touched upon, the author having dealt

with industry in general. He quite agreed that to deal with industry in general was to deal with the question of unemployment; but there was a specific problem of unemployment, and up to the present that problem had not been carefully, sufficiently or properly considered. He would like to remind the audience that up to the present moment Labour had had no hand whatever in the direction or control of industry, and, therefore, the problem of unemployment had been one for the captains of industry; and he wished that such gentlemen had approached it in the spirit in which the author had approached it that night. He would point out that the only provision which had been made for unemployment up to within very recent years had been that made by Labour itself—by the Trade Unions of the country. Nobody else had thought of making any provision, and neither the author nor anybody else, therefore, must be surprised at some of the manifestations which they saw to-day. The solution of unemployment was a very grave national problem, and that solution must be sought and must be found. Up to the present moment no complete solution had been found. The author had stated that he (the Chairman) was a member of the Executive of the Industrial League and Council. What did that League seek to do? It said that, with regard to the problem of unemployment and all other industrial problems, the solution should not be sought alone by either one side or the other. He spoke of "sides," but he thought the sooner the idea was got rid of that there were any sides in the business at all the better. When that idea was dispelled the next step to take was to seek a joint solution of the problems connected with unemployment. If employers and workmen understood their own interests to the full, they would realise that no possible solution could be arrived at which was not a joint solution, and one which they were both determined to bring about.

He had been extremely interested in the paper. He did not think the author quite knew how far he had gone. When he (the Chairman) had been a member of the Labour Party in very active service, that party had been told, when they had brought in their Right to Work Bill in Parliament, that they were undermining the whole constitution of industry and of the country. But what was Mr. de Segundo's real panacea for the problem? It was that there should be an industrial army, and that when that industrial army was not at work it should be paid, just as the policeman, the soldier and the sailor were paid their wages when they were not on active service. That was a revolution in industry. It was a revolution which the Right to Work Bill had sought to put upon the Government. He was not concerned to argue at the moment whether the cost of keeping the industrial army should be put upon the country, the employer or the employed: all he was pointing out was that the author had admitted in the paper the principle that if the worker registered himself in the industrial army he should be provided with some means of keeping himself alive when he was not on active service. The fear of unemployment, and actual unemployment, was a nightmare to the working classes. There was nothing they feared more. He was quite willing to agree that when people were in work they should provide for a rainy day, but he wondered if all capitalists did that. The margin in the one case and in the other was very different, and it was that margin which made all the difference in the world. Even supposing it were possible for each person by great thrift to make provision for a rainy day, that was not a proper and reasonable solution of the problem. There must be a solution found for the problem of unemployment, which he looked upon as the most grave industrial problem of the time. He would never believe it was beyond the possibilities of statesmanship and common-sense and industrial efficiency in this country to find such a solution. He believed that the solution would be found partly in the idea of insurance, and partly through a re-organisation of our industrial system: but he repeated that, so far as he was concerned, he thought no solution was possible unless and until employers and employed were willing to meet together and discuss the problem around a table and work together. Therefore it was that he welcomed the fact that the Royal Society of Arts had opened its doors to the discussion of the problem, and he expressed the earnest hope that the meeting would re-echo through the country and would force everybody to see that somehow or another a solution to the problem which threatened the nation at the present time must be found.

Mr. John Baker said he was sorry that the author had not approached the problem in a spirit that was going to tend towards a solution of it, but had approached it in that very spirit which he condemned in the workers. It was stated in the paper that during the war period Labour, meaning organised Labour, had abused its power in regard to wages. That statement was absolutely and emphatically untrue. No broad mass of the principal industries of this country since 1914 had had a single advance in wages which had not had to be submitted to arbitration, and which had not had to be based upon the argument of the increased cost of living. If that statement was true Labour had not used its power at all, much less had it abused it. In the early days of the war, Labour had withdrawn from the employers every claim that it made for advances of wages, every claim for reduction of hours, and every claim for improvement of conditions, and it had urged upon the Government that they should control industry and keep prices down. It was the

only section of the community that had taken up that attitude. But prices went up, and wages followed prices. The general earnings of the workers of this country had been reduced by one million pounds per month within two months of the outbreak of war, and had not recovered until after the middle of 1915. Prices of foodstuffs in the country had increased by 16 per cent. within eight days of the outbreak of war. Men could not be expected to live on starvation wages if the prices of goods were doubled; it was not a reasonable proposition. Then men asked for advances. They waited for nine months and did not get them. The Government then passed a Bill which instituted tribunals whereby it was impossible for one workman to leave one works and go to another without the permission of that tribunal. Yet the author talked about Labour using its power. It was nonsense. After that a commission had been sent throughout the country, which reported to the Government that undoubtedly the ever increasing prices were the chief cause of the unrest existing in the country at that time, and the Government set up an Industrial Court. Before that Industrial Court no other argument weighed than the increased cost of living. It was stated that Labour had increased the margin between wages and the increase in the cost of living. He suggested that the author had not made a single enquiry as to the truth of that statement, and had not given a single figure to bear out its correctness. The statement was not true. The average wage of the members of the Amalgamated Society of Engineers had not increased at the same rate as the cost of living had increased. Those men in a skilled industry were in a worse economic position now than they had been in 1913. There was the outstanding fact that the wealth of this country from 1914 to 1920 had almost doubled. Dr. Stamp's own figures showed that the wealth production of 1914 was £2,100,000,000, and that the 1920 figure could not exceed £4,000,000,000; he believed it was more than £3,900,000,000, and in all probability the proper estimate was £3,950,000,000. The wealth of the country was increasing by leaps and bounds, but the wages of the workers had to stay where they were. Why was that so? He himself was a worker, and he was going to see to it that the wages of the workers of this country were not going to stay where they were in the face of such an increased wealth productivity. The wages of the iron and steel workers were regulated by Boards of Arbitration. The wages followed the selling price of the product. The wages had increased about 200 per cent., but prices had increased 400 per cent. The author, and gentlemen who took his view, were up against the awkward predicament that they had to explain how 200 per cent. on one item of cost was going to increase the total cost by 400 per cent. There was some other body outside the workers which was using its power.

Professor John A. Todd said he did not agree with the author in his explanation of the immediate causes of the present trade slump. The author put it down mainly to the fact that consumers had found themselves up against a level of prices which they simply could not pay. It had been his (the speaker's) business for the last two years to watch for the slump, and it seemed to him that what had happened was that up till 12 months ago there had been a very distinct tendency towards improved trade, increased demand and rising prices. Then all of a sudden there occurred a complete change. The cause of it had been finance—a change in the financial atmosphere of the country. The attitude of the consumers came later. The consumers had been buying as fast as they knew how, and, while they had grumbled at the prices, they had been prepared to go on buying a good deal longer; but what had happened was that a great cry arose of deflation and falling prices, and the consumers said: "If prices are going to fall we will wait until they do." The consumers' strike occurred after the beginning of the fall of prices. It had been the result of the deflation talk. It had not been the cause of the first beginning of the fall of prices, but the result. That had had a very peculiar effect, and he thought most people who were watching conditions at the present moment would be bound to admit that there was some truth in it. What had happened was that there had been a tendency towards a fall in prices, a tendency for the consumers to hold back and refuse to buy until prices came down, and also a tendency for the wholesalers and the manufacturers to say, "We will bring prices down as soon as we have got rid of our stocks." The consumers then said, "We will buy your stocks as soon as prices come down," and there had been a deadlock which had lasted for nine months, until it had been broken in the textile trade at the sales in the previous month. That deadlock had been the cause of unemployment. There had not been any real reason why there should have been that unemployment. It had been more a financial deadlock, as well as a political and foreign exchange deadlock, than a real state of affairs that should have produced unemployment. There had been no glut of the world's markets, and there had been no over production. The world was still very short of goods of all kinds. There were men anxious and willing and able to produce those goods. The producer was walking the street looking for a job, and the would-be consumers were looking for goods, and they could not get them or could not get the money to pay for them. There was something deadly wrong in the whole system. Personally, he thought that many of the working classes were probably better informed on economic questions than were the masters. There was one thing which a good many of them could not have failed to notice just lately, namely, that there was only one

commodity in the world that had gone up in price substantially in the last nine months, and that was money. Everything else had gone down. One could not help feeling that while unemployment was the nightmare of the working classes, it was the opportunity of the employers. He would not say that employers in this country had taken advantage of this opportunity, but he had very grave suspicions that in America employers had done so. Of course there were many things to be said on the other side. For instance, to take Mr. Baker's argument that because the wealth of this country had increased during the war from £2,200,000,000 to about £4,000,000,000, therefore the working classes should get higher wages; that was simply ignoring the application of Mr. Baker's own argument. The increased wealth was in nominal prices. If one deducted the rise of prices and put it back to the old level of prices, the result was that the country was no better off than it was before the war. He did not believe that there was any one thing that would cure the whole problem. He had great doubts about the author's industrial army. He did not believe the country could afford it. He did not believe the country could escape the obvious abuses of such a system, and he thought it would lead to very great difficulties if the suggestion was adopted. What he did plead for, quite apart from class interest, was a much more sympathetic attitude towards Labour questions from people of other classes. Was it very absurd that in big factories with big capital and big labour forces, some of the workmen should be put on the directorate? Personally, he did not believe they would do very much good; he did not believe they would represent the working class view very much better than they did at the present time, but he did believe they would learn a very great deal. A working man put on as a director would find out how little he knew about the difficulties and the risks and the serious responsibilities of being a big employer of labour. A little mutual knowledge like that would go far further towards producing a friendly settlement of the question of unemployment than almost anything else which could be imagined.

THE RIGHT HON. LORD ASKWITH, K.C.B., K.C., D.C.L., remarked that all that the author had said showed there was no absolutely uncontroversial form of settlement, nor was there any one form of settlement, of the problem of unemployment; that the cure for unemployment could not be got by a wave of the hand, nor could it be got in a sudden moment. It was a question which required enormous study and enormous co-operation between people in order to get at the best solution with regard to different people, different trades, and, he might almost say in many cases, different individuals. Human nature was not all of one kind, and similar medicines, even for the same kind of disease, very often affected patients in different ways. He had in other writings indicated with much diffidence that some of the points which appeared to be most important in the matter were education, forms of insurance, and mutual co-operation between employers and employed. With regard to unemployment generally in different trades, he had over and over again stated his view that the principle to aim at was that each trade or group of trades ought to try to find its own solution. The author had led up finally to a sort of army of industry, which was to be entered by education, and guided by a moral code. That was a very nice prospect to look forward to, but he thought, even if it were accomplished, it was a matter which would take a considerable time, and that it was not an immediate prospect at the present moment. He agreed that perhaps the present unemployment was to a certain extent unexpected. It was to be hoped that it was also to a certain extent transitory. But it had come, and it showed the importance of discussing the matter in times of better prosperity, with all our brains and power, in order to find a solution of the difficulty, so that panic-stricken measures should not be taken when the sudden emergency arose.

THE RT. HON. G. H. ROBERTS, M.P., remarked that if he had found the paper lacking in a great many details, he also had to confess that much of the discussion which had ensued had failed to give him much enlightenment on the great problem of unemployment. It appeared to him that it was no good indulging in recriminations as between class and class. The first question he would like to be confronted was: was there any solution of the problem? He ventured to reply—although he might be misunderstood—that there was no such thing known as an absolute solution of the unemployment problem, because, after all, the industries of this country and their relation to the industries of the world were so complex and intricate that he could not even imagine it possible to organise them so perfectly at home and abroad as to ensure even to every willing worker fifty weeks' work every year. Therefore, he thought it had to be recognised that there would be periods of depression from time to time, whatever was done. The present problem was unprecedented in history. The world was crying for goods, and Labour was anxious to exercise itself in the manufacture of goods; but it was a very remarkable thing that the world stopped buying, not because it was satiated with goods, but because the price of those goods had reached a point where there was a revolt, and not an actual lack of purchasing power. It was a revolt of the consumers of the world against the point to which prices had been forced. It had to be recognised that if employment was to be found for our people in the future there must be markets, and those markets

would only be open to us if the prices of the goods we had to sell compared favourably with those of our competitors. If we were unable to produce on equal terms with our competitors then we would fail to sell, and the unemployment problem would grow in extent, not according to the will and caprice of the employers, and workmen would be compelled to suffer an all-round reduction of wages, not because a wicked body of men called capitalists had met together and had decided on a conspiracy, but because of the sheer economic fact that for some cause or another—either inefficiency on the part of the capitalist or lack of endeavour on the part of the workman—we were unable to produce goods at a price which would compete with the prices of our competitors. That was a fact which employer and workman alike ought to consider. Great Britain more than any other country in the world was dependent on foreign trade. He was not advocating any system of tariffs, but merely that it was incumbent upon the employers and workers in every industry to come together and study the conditions of their industries, and to ascertain why it was that foreign competition was able to cut them out in the markets of the world.

MR. A. E. PARNACOTT said so far as the propaganda of the agitator was concerned, the antidote for that was counter-propaganda. It seemed to be a fact that the well-intentioned agitators, as they got fuller knowledge of the subject, departed from the Labour movement and went into other spheres either as servants of the Government or in other directions, and it seemed to him that such men would be very valuable in carrying on counter-propaganda. He considered that one way of getting over many of the difficulties in connection with Labour at the present time was a profit-sharing scheme.

MR. C. W. GIBSON remarked that he was an official of the General Labourers' Union, and would not have taken part in the discussion had it not been that one of the things which seemed to have been insisted upon that night was that there must be confidence between employers and employed if the problem of unemployment was going to be solved. He took it that "confidence" implied that both sides were ready to play the game. One of the previous speakers had said that he had a suspicion that in the United States employers were deliberately taking advantage of the present unemployment in order to reduce wages, but that the employers of this country were not doing so. That had not been his (the speaker's) experience. Within the last fortnight he had had three occasions to interview employers on that very question. The employers had not said "We want to discuss the question of reducing our labour costs with you," but they had merely put up a notice that after such-and-such a date wages would be reduced by so much. That kind of thing naturally introduced a great deal of dissatisfaction and trouble. He agreed with Mr. Roberts that there was no one solution for the problem of unemployment. He believed that, under the best and most ideally organised system of society, some people would be out of work, but those people had to be provided for. But there was a vast difference between that and the enormous number of men and women who were now walking about the streets unemployed. He knew from his own knowledge that there were hundreds of men who would work at any job at any rate of wages which was offered to them. He had been told by one employer the previous week—an employer with whom there was a written agreement that the rate of wage should be £4 *5s. 0d.* a week—that a man with a wife and six children had come to him and had offered to take the job at 30*s.* a week. He (the speaker) could quite understand the man's attitude, but there was the fact that the men in that particular trade, for the sake of their own wives and families, could not allow that man to start at 30*s.* a week. Unfortunately, however, there were some employers who would immediately take that man on at that rate of wage. In conclusion he agreed with Mr. Baker that many of the things which the author had said had been extremely unkind, and not at all in accordance with the facts.

MR. DE SEGUNDO, in reply, said he really thought that Mr. Baker had misunderstood him, and he dared say that if they got together quietly they would find they were in more agreement than they thought they were. A certain wise man had said that nearly all the controversies in the world were verbal ones, and that if each man knew what the other meant it would probably be seen at once that controversy was either hopeless or unnecessary. It was quite possible for two people with the best possible intentions in the world to get at loggerheads. He had had no intention of saying anything that would wound the feelings of the representatives of the true Labour movement with which he had every sympathy. The main objectof his paper had been to direct attention to the fact that the mind of the country was being distracted by internal dissensions from the vitally important question of the loss of our foreign markets, and that unless our foreign trade was maintained it would soon become impossible for Great Britain to support its present population, with the inevitable consequence that we should cease to be a first-class Power.

On the motion of the Chairman, seconded by Mr. Baker, a hearty vote of thanks was accorded to the author for his paper.

STRAW BRAID INDUSTRY IN SHANTUNG.

Upon the opening of the port of Chefoo to foreign trade and residence in 1862, it was found that an important local industry existed in the plaiting of straw and the making of hats for the Chinese. Foreign exporters promptly saw the opportunities for trade with Europe in straw braid, and exports started from Chefoo, the braid going forward in sailing ships. At that time the local braids were known as Chefoo white, mottled, rustic and pearedge.

In the early days of exporting, braid was purchased by weight, the unit being the picul (133⅓ pounds). This method was later abandoned as the makers soon found that soaking the braid in water greatly added to its weight, although as a consequence, on the long journey to Europe the braid was ruined. Purchasing by the bale was then introduced, but no definite standard was established, the contents being noted by the number of pieces of special length. Later standard units were adopted and packages now consist of either 240 or 480 pieces of 30, 60 or 120 yards per piece. This standard has been definitely accepted by the Chinese.

Original patterns were all made of whole straw, but later, with the growth of the industry, Swiss and Italian fancy patterns were copied. With a view to plaiting lighter and more attractive braid the splitting of straw was started, and higher grade patterns are now plaited with split straw. As a substitute for Italian pedal, Laichow mottled braid was introduced and soon found a world-wide market.

The industry, under foreign impetus, has grown to such vast proportions that it is the main source of income for a considerable proportion of the population of north central Shantung Province. It has also extended to other Provinces, mainly Chili and Shansi. In fact, wherever wheat is grown straw braid is plaited.

Following the establishment of an important straw-braid market at Chefoo, exporters at Tientsin and Shanghai became interested, and later, after the building of Tsingtau, that city became an important market for braid. With the completion of the Shantung Railway and the more convenient transportation facilities offered, the trade was diverted from Chefoo to Tsingtau. Upon the outbreak of the European War Tsingtau was besieged and eventually captured by the Japanese, and of necessity the trade routes were altered again, bringing Chefoo forward as the straw-braid market. This, however, was only temporary, as Chefoo's handicap in not having rail communication with the interior makes it impossible to hold this trade. Should the Chefoo-Weihsien Railway be built there seems little doubt that Chefoo will be able to hold its own as an important straw-braid market, but it is doubtful if it will ever again become the premier market in China for this article.

From a report on the straw braid industry of Shantung by the U.S. Consul at Chefoo, it appears that the main producing centres of Shantung Province are in the Tsinanfu district and to the westward of the Chefoo district; and the most important centres of Northern Shantung are Shaho, Laichow, Pingtu, Changi, Showkwang and Yangsin, from which Chefoo draws its supplies. Of these centres only Laichow is in the Chefoo district. Braid from these districts is collected at Shaho, where it is re-assorted, packed, and transported to Weihsien on the Shantung Railway, to be marketed in Tsingtau and Tientsin, at present only relatively small quantities going to Chefoo. Sinchwang, Chaocheng and Kwangcheng are the producing centres of the western part of Shantung Province, with Nanlo, in Chili Province, and Tenghsien, Ningyang and Matow in the southern part of the Shantung Province.

The districts of northern Shantung produce the best grade and highest priced straw braid, and it is the better qualities and kinds of this braid which are marketed through Chefoo. Piping and split and all kinds of fancy-split patterns are made in this region. Laichow and Tientsin mottled, which are made in Sinchwang in western Shantung, no longer enter the Chefoo market, being conveyed by rail either to Tientsin or Tsingtau. Chaocheng and Kwangcheng mottled, also known as Laichow mottled, are the other principal braids of western Shantung. Prior to the building of the Shantung Railway these were all brought overland to Laichow and marketed in Chefoo.

The producing centres of south Shantung are of lesser importance, Tenghsien producing a small quantity of mottled braid and Ningyang plaiting two main qualities known as Ningyang white and Nangyang Tuscan. Matow formerly produced, in considerable quantities, a braid known as Matow Tuscan, which was marketed in Chefoo and also sent direct to Shanghai by junk, but at present this braid is not on the market, being out of fashion. Practically all the straw braid of Shantung Province is made of wheat straw, the only exception being a small amount of rustic braid made from barley straw.

During German occupation of the Kiaochow Peninsula serious efforts were made to introduce this industry into the neighbourhood of Tsingtau, but without success.

Foreign markets for straw braid are governed by changing fashions, and consequently great uncertainty prevails as to the probable future demand for any particular kind. Generally speaking, higher prices are paid in the American market than in London, and it usually follows that when the demand in America becomes slack the London market becomes active, and *vice versa*. Frequently American buyers cease direct importations from China and make

their purchases in the London market. France is a fairly heavy buyer, the trade for the entire country being centred in Paris. The smaller markets of the world are supplied by New York, London and Paris, and before the war Dresden, with China braids.

Straw used for making braid is sorted according to length and size, and the plaiting is done entirely by hand, the straw first being moistened in water to make it pliable. Comparatively small quantities of braid are made from whole straw. The straw is split by inserting a sharply pointed instrument with a varying number of cutting knives on the sides, the straw being split into pieces of equal width as desired. Fine straws are usually split into from three to five pieces and coarser straws up to seven pieces. The braid is then plaited according to the desired pattern of a uniform width throughout and the small projecting ends of straw are rubbed off. The finished braid is wound into bundles on specially built tables and over two wooden pegs, set so that their outside measurements will be exactly 16 inches apart. This not only ensures the bundles being uniform in size, but it also measures the braid.

The table on which the braid is wound is grooved crosswise in three places between the two pegs and twine is slipped along the grooves and under the bundle for convenient tying. The finished bundles are then placed in a box with wet sulphur in the bottom, and the fumes bleach the straw. In the trade this is not considered bleached braid, as it must undergo a proper bleaching process abroad before it can be used in the manufacture of hats and baskets. After this process the braid is delivered to the nearest collecting point, where it is assorted and packed and forwarded to the principal markets of the locality, such as Tientsin, Shanghai, Tsingtau or Chefoo. There it is unpacked, properly sorted, graded into qualities, and accurately measured, and all braids of the same quality, kind and exact size are finally packed for shipment abroad. Each bundle, which is known to the trade as a piece, is tied separately, and is either 30, 60 or 120 yards in length, and a package consists of either 240 or 480 pieces. High-grade straw braid made of split straw is packed in wooden cases for foreign shipment and plain braid, made of whole straw, is packed in bales.

Luton is the most important centre for the bleaching and dyeing of straw braid and the place where the art has reached its highest perfection. With altered trade conditions brought about during the war, and the fact that America is the greatest purchaser of straw braid and that American importers are steadily increasing their direct purchases from the country of supply, there is every reason to believe that in conjunction with the new dye industries in America the bleaching and dyeing of straw braid will become an important industry in the United States.

The exports of straw braid from Chefoo during 1918 increased about 20 per cent. over the 1917 shipments, but this may be considered as only a temporary gain due to existing local conditions, and upon the return of normal conditions in Tsingtau it is expected that the trade will return to that port unless Chefoo's interior transportation facilities are adequately improved. The total exports of straw braid from China are valued at approximately £600,000 per annum.

ESSENCE OF BERGAMOT INDUSTRY IN SICILY.

Among the minor items in the list of exports from Italy an important place may be assigned to essence of bergamot. According to a report by the U.S. Commercial Attaché at Rome, Italy's supply of essence of bergamot is derived from the island of Sicily. The plant belongs to the rue family, and the product of the distillation of the roots of this plant is known at essence of bergamot. The Italian Government has been at great pains to protect the industry by keeping this Sicilian product up to certain specified standards. The Sicilian peasant is at perfect liberty to distil bergamot root as he pleases, but the product may not be put upon the market until it has been brought to the Government laboratory at Messina and analysed and graded. It is then placed in copper receptacles and sealed by Government officials to prevent adulteration. While the stuff is not sold by the Government, it is sold under Government inspection. Essence of bergamot forms the base of many proprietary perfumes, and the demand for this Sicilian product is steadily increasing.

It is said that essence of bergamot in former times found its way to the American market through French and British intermediaries. That is no longer true. American agents are not only to be found in Sicily as purchasers of the distilled product after it has passed Government inspection, but they also go to the original peasant producer and buy options on the crops some months in advance of the period of actual distillation.

PRODUCTION OF TOBACCO IN JUGO-SLAVIA.

The most productive tobacco growing region in Jugo-Slavia is Serbia, which, within its frontiers of 1912, produced annually about 2,000,000 kilogs (4,409,000 lbs.), of which it consumed only 900,000 kilogs; the remainder being exported in leaf. The total production of Serbia and Macedonia, according to *Trgovinski Glasnik* (a trade journal) has increased to more than 4,000,000 kilos.

From a recent report by the U.S. Chargé d'Affaires at Belgrade, it appears that tobacco is extensively cultivated in the following regions:

In the Department of Skoplje, 500,000 kilos; in that of Bregalnitza (exclusive of the district of Strumitza), about 600,000 kilos; in the Department of Prilep, about 500,000 kilos; in Koumasovo, 600,000 kilos; in Vragais, 250,000 kilos; in Nish, 600,000 kilos; in Kruchevats, 300,000 kilos; and in Oujitse, 100,000 kilos.

Before the war, Herzegovina produced 3,500,000 kilos of tobacco, and there have been occasional harvests when the crop reached 4,600,000 kilos. The next crop, however, because of the post-war conditions, will not exceed 500,000 kilos. The most productive sections are in the south and east, the district of Mostar, Loubouchka, Stilats, Soubigne and Trebigne, as well as certain communes of the districts of Biletche and Kognits.

In Bosnia, the eastern sections are the most productive, especially the districts of Srbrnitsa, Vlasenitsa, and Svornik. In the north-east, the production is extensive in the districts of Belina, Brtchko, Gradatchatch, Bihatch and Sazin; in the south, in the districts of Prozor, Totcha and Tchainitche. Bosnia yields about 500,000 kilos of tobacco annually.

In Dalmatia the cultivation of tobacco has increased steadily since 1884; in 1913 it reached about 3,500,000 kilos, but since the war the production has decreased.

The exact amount of the crop in the Banat, the Batchka, the Baranya, and in Croatia and Slavonia is not known; but, according to Hungarian statistics, Hungary yielded 6,000,000 kilos, of which approximately 4,000,000 were produced in these Provinces. The most renowned tobacco sections of that portion of Hungary which have been awarded to Jugo-Slavia are: In the Banat, the districts of Vielki, Botchkorek, Jombal and Tcheka; in the Batchka, the central and northern districts in the Baranya, Boertch; in Croatia and Slavonia, Virovititsa Pogega, Pakrats, and Slatina.

The annual tobacco crop of Jugo-Slavia, therefore, approximates 15,000,000 kilos. Of this, some 6,000,000 kilos are required for domestic consumption, leaving 9,000,000 kilos for export, either in the leaf or prepared for immediate use.

GENERAL NOTE.

Chicle Gum in British Guiana.—Announcement has been made in a report submitted by the U.S. Consul at Georgetown, of the discovery of chicle-producing trees in British Guiana. Prospecting expeditions sent into the interior have returned to Georgetown with 600 pounds of chicle, and preparations have been made by the discoverer, who holds a concessionary right over 6,200 square miles of territory, to send out four prospecting parties in order to continue investigations and ascertain the productive capacity of the district. Territory thus far examined is reported to be capable of yielding 200,000 pounds of gum annually.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

March 16. — Charles Ainsworth Mitchell, M.A., F.I.C., "Science and the Investigation of Crime." The Right Hon. Lord Justice Atkin in the Chair.

April 6.—Professor Archibald Barr, D.Sc., LL.D., M.Inst.C.E., "The Optophone."

April 13.—Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Low Temperature Carbonisation and Smokeless Fuel."

Indian Section.

Fridays at 4.30 p.m.

April 22.—Lieut.-Colonel Sir Edward W. M. Grigg, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

May 27.—William Raitt, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

Indian and Colonial Sections.

(Joint Meeting.)

At 4.30 p.m.

Tuesday, May 3.—Sir Charles H. Bedford, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

Sir James P. Hinchliffe, "Research in the Wool Industry."

Sir Herbert Jackson, K.B.E., F.R.S., "Research in Scientific Instrument Making."

John Francis Crowley, D.Sc., B.A., M.I.E.E.

Dr. C. M. Wilson, "Industrial Medicine."

William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology,

"Brown Coals and Lignites: their Importance to the Empire."

Cantor Lectures.

Major G. W. C. Kaye, O.B.E., M.A., D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures.

Syllabus.

Lecture II.—March 14.—High Potential Generators—Open and Closed Coil Transformers—Influence Machines—Homogeneous X-rays—X-ray Measurements—Intensity and Wave-Length—Characteristic X-rays—X-ray Spectroscopy.

Lecture III.—March 21.—Applications of X-rays to Various Branches of Industry—X-rays in Medicine—Future Developments and Improvements.

Samuel Judd Lewis, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

MEETINGS FOR THE ENSUING WEEK.

Monday, March 14 .. Cold Storage and Ice Association at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m.

University of London, King's College, Strand, W.C., 5 p.m. Mr. W. G. Ridewood, "The Vertebræ of Elasmobranch Fishes."

Electrical Engineers, Institution of, at the Chartered Institute of Patent Agents, Staple Inn Buildings, Holborn, W.C., 7 p.m. Mr. R. L. Morrison, "Rectifiers."

Surveyors' Institution, 12, Great George Street, S.W., 7 p.m. (Junior meeting.) Mr. J. G. Elsworthy, "Conversion of Buildings to meet Modern Requirements."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. H. P. Adams, "Cottage Hospitals."

Transport, Institute of, at the Institution of Civil Engineers, Great George Street, S.W., 5.30 p.m. Major General Sir F. H. Sykes, "Civil Aviation."

Tuesday, March 15 .. Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Mr. J. Kewley, "The Crude Oils of Borneo."

Aeronautical Engineers, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 8.30 p.m. Dr. A. P. Thurston, "Points in the Design of Aircraft Structures."

Sociological Society, 65, Belgrave Road, S.W., 5.15 p.m. Mr. L. Simon, "The Hebrew University in Jerusalem."

Royal Institution, Albemarle Street, W., 3 p.m. Dr. A. Keith, "Darwin's Theory of Man's Origin in the light of Present Day Evidence." (Lecture IV.)

Electrical Engineers, Institution of (North-Eastern Centre), Armstrong College, Newcastle, 7.15 p.m.

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. The President, "Church Decoration in the Early and Middle Ages."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Mr. E. Torday, "Culture and Environment. Cultural Differences among the various branches of the Batetela."

African Society, Connaught Rooms, Great Queen Street, W.C., 8 p.m. Earl Buxton, "Presidential Address."

Statistical Society, at the Surveyors' Institution, 12, Great George Street, S.W., 5.15 p.m. Sir James Wilson, "The World's Wheat."

Wednesday, March 16 .. Imperial Arts League, at the Royal Society of Arts, John Street, Adelphi, W.C., 5 p.m. Annual General Meeting.

Meteorological Society, at the Royal Astronomical Society, Burlington House, Piccadilly, W. 1., 5 p.m. Dr. G. C. Simpson, "The South-West Monsoon."

Electrical Engineers, Institution of (Wireless Section), at the Institution of Mechanical Engineers, Storey's Gate, S.W., 6 p.m. 1. Mr. G. Stead, "The Effect of Electron Emission on the Temperature and Anode of a Thermionic Valve." 2. Miss W. A. Leyshon and Dr. W. H. Eccles, "Some Thermionic Tube Circuits for Relaying and Measuring."

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W., 11 a.m. 1. Address by the President (the Duke of Northumberland). 2. Sir Eustace D'Eyncourt, "Notes on Some Features of German Warship Construction." 3. Mr. S. V. Goodall, "Ex-German Battleship 'Baden.'" 4. Mr. W. R. G. Whiting, "The Strength of Submarine Vessels."

United Service Institution, Whitehall, S.W., 5.30 p.m. Captain A. Dewar, "The Necessity for the Compilation of a Naval Staff History."

Thursday, March 17 .. Aeronautical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Captain D. Nicolson, "Flying Boat Construction."

Illuminating Engineering Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 8 p.m. Major A. Garrard, "Motor Car Head-lights: Ideal Requirement and Practical Solutions."

Royal Society, Burlington House, W., 4.30 p.m.

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W., 11 a.m. 1. Messrs. R. J. Walker, and S. S. Cook, "Mechanical Gears of Double Reduction for Merchant Ships." 2. Mr. E. W. Blocksidge, "Life-Saving Appliances on Cargo and Passenger Vessels." 3. Mr. M. E. Denny, "The Design of Balanced Rudders of the Spade Type." 3 p.m. Mr. H. B. Wyn Evans, "Standardization of Data for Airship Calculations." 8 p.m. Professor T. B. Abell, "A Study of the Framing of Ships."

Royal Institution, Albemarle Street, W., 3 p.m., Dr. G. C. Simpson, "The Meteorology of the Antarctic." (Lecture II.)

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Sir W. Noble, "The Long Distance Telephone System of the United Kingdom."

Numismatic Society, 22, Russell Square, W.C., 6 p.m.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m. Annual General Meeting.

Architects, Society of, 28, Bedford Square, W.C., 8 p.m. Mr. H. Bagenal, "Acoustics."

Friday, March 18 .. Technical Inspection Association, at the Royal Society of Arts, John Street, Adelphi, W.C., 7.30 p.m.

Royal Institution, Albemarle Street, W., 9 p.m. Sir Frederick Bridge, "Researches of a Musical Antiquarian."

Metals, Institute of, Mappin Hall, Sheffield, 7.30 p.m. Dr Rosenhain, "The Crystal Boundary."

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W. 11 a.m. 1. Mr. K. G. Finlay, "On the Spacing of Transverse Bulkheads." 2. Mr. A. M. Robb, "Deflections of Bulkheads and of Ships." 3. Mr. J. J. King-Salter, "Some Experiments on Tallows in their Use for the Launching of Ships."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m.

Saturday March 19 .. Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Electricity and Matter." (Lecture III.)

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FRIDAY, MARCH 18, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 21st, at 8 p.m. (Cantor Lecture.) MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." (Lecture III.)

CANTOR LECTURE.

On Monday evening, March 14th, MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc., delivered the second of his course of lectures on "X-Rays and their Industrial Applications."

The lectures will be published in the *Journal* during the summer recess.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 9th, 1921; VISCOUNTESS ASTOR, M.P., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Arnhold, Charles Herbert, London.
Bedford, James Edward, F.G.S., Headingley, Leeds.
Pearson, Colonel Henry Lawrence, D.S.O., Singapore.
Sen, Percy Arnold, Lucknow, India.
Stone, Lieut. Ellery Wheeler, U.S.N., R.F., San Francisco, California, U.S.A.

The following Candidates were balloted for and duly elected Fellows of the Society:—

Beardsell, Sir William A., Madras, India.
Bejal, Shiv Shankar, Morar, Central India.
Boyce, Eduljee M., B.A., Jhansi, United Provinces, India.
Bristow, Robert C., Cochin, S. India.
Chan Heang Thoy, J.P., Perak, Federated Malay States.
Hughes, William O., Bangor, N. Wales.
Kaul, Diwan Bahadur Sir Daya Kishan, K.B.E., C.I.E., Patiala, India.
Waring-Brown, Robert, A.M.I.A.E., Coventry.

A paper on "The Plumage Trade and the Destruction of Birds" was read by WILLOUGHBY DEWAR, Honorary Secretary of the Plumage Bill Group.

The paper and discussion will be published in a subsequent number of the *Journal*.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1921 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 26th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce," and has been awarded as follows in previous years:—

1864, Sir Rowland Hill, K.C.B., F.R.S.
1865, His Imperial Majesty, Napoleon III.
1866, Michael Faraday, D.C.L., F.R.S.
1867, Sir W. Fothergill Cooke and Sir Charles Wheatstone, F.R.S.
1868, Sir Joseph Whitworth, LL.D., F.R.S.
1869, Baron Justus von Liebig.
1870, Vicomte Ferdinand de Lesseps, Hon. G.C.S.I.
1871, Sir Henry Cole, K.C.B.
1872, Sir Henry Bessemer, F.R.S.
1873, Michel Eugène Chevreul.
1874, Sir C. W. Siemens, D.C.L., F.R.S.
1875, Michel Chevalier.
1876, Sir George B. Airy, K.C.B., F.R.S.
1877, Jean Baptiste Dumas.
1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S.
1879, Sir William Thomson (afterwards Lord Kelvin), O.M., LL.D., D.C.L., F.R.S.
1880, James Prescott Joule, LL.D., D.C.L., F.R.S.
1881, Professor August Wilhelm Hofmann, M.D., LL.D., F.R.S.
1882, Louis Pasteur.
1883, Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1884, Captain James Buchanan Eads.
1885, Sir Henry Doulton.

MEETINGS FOR THE ENSUING WEEK.*

MONDAY, MARCH 7 .. University of London, at the Royal Society of Medicine, 1, Wimpole Street, W., 5 p.m. Dr. C. M. A. Kappers, "Structural Laws in the Central Nervous System; the Principles of Neurobiotaxis."

At the Institution of Civil Engineers, Great George Street, S.W., 5.30 p.m. Professor L. Luiggi, "Recent Engineering Works in Italy." (Lecture I.)

Post Office Electrical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m.

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev. H. C. White, "Public School Education."

Engineers, Cleveland Institution of, Corporation Road, Middlesborough, 6.30 p.m.

Royal Institution, Albemarle Street, W., 5 p.m. General Monthly Meeting.

Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. R. W. A. Brewer, "Some Modern Engineering Practice in America."

Chemical Industry, Society of (London Section) at the Chemical Society, Burlington House, W., 8 p.m. 1. Dr. J. C. Drummond, "Factors Influencing the Food Value of Lard and Lard Substitutes." 2. Dr. R. C. Farmer, "The Stability of Benzoyl Peroxide."

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m. Mr. A. B. D. Lang, "The Report from the Select Committee of the House of Commons on Business Premises."

Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. J. H. Driberg, "The Lango District, Uganda Protectorate."

Electrical Engineers, Institution of, at the South Wales Institute of Engineers, Cardiff, 7 p.m.

TUESDAY, MARCH 8 .. Transport, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m.

University of London, Royal School of Mines, South Kensington, S.W., 5 p.m. Professor W. W. Watts, "The Geological Work of Charles Lapworth" (Lecture I.).

Royal Institution, Albemarle Street, W., 3 p.m. Dr. A. Keith, "Darwin's Theory of Man's Origin in the Light of Present Day Evidence." (Lecture III.)

Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m.

Geological and Mining Society, Manchester, 4.0 p.m. Mr. J. Lomax, "The Various Forms of Pyrites in Coal. Their Probable Origin and Effects on being Exposed to Atmospheric Influences."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Annual General Meeting.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Professor F. G. Parsons, "The Head Form of the Long Barrow Race, with reference to the Modern Inhabitants of London."

Zoological Society, Regent's Park, N.W., 5.30 p.m.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Mr. J. W. McConnel, "Cotton Growing within the Empire."

Horticultural Society, Vincent Square, Westminster, S.W., 3 p.m.

Electrical Engineers, Institution of, Hote Metropole, Leeds, 7 p.m.

Electrical Engineers, Institution of, 17, Albert Square, Manchester, 7 p.m. Mr. A. B. Mallinson, "Electric Driving in the Paper Mill on Heat Economy Lines."

Electrical Engineers, Institution of, Princes Street, Station Hotel, Edinburgh, 7 p.m. Sir W. Noble, "The Long Distance Telephone System of the United Kingdom."

Automobile Engineers, Institution of, The Quadrant, Coventry, 7.15 p.m. Mr. G. M. Martineau, "Current Motor Cycle Frame and Chassis Design."

Metals, Institute of, 39, Elmbank Crescent, Glasgow, Annual General Meeting, 8 p.m., Address by Mr. J. Steven.

Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m. Mr. S. Leggett, "The Amritsar Hydro-Electric Irrigation Installation."

WEDNESDAY, MARCH 9 .. Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Rev. J. Steele, "The Animistic Basis of Eastern Religions."

Geological Society, Burlington House, W. 5.30 p.m. Mr. W. B. R. King, "Surface of the Marls of the Middle Chalk in the Somme Valley and the neighbouring parts of Northern France, and the effect on the Hydrology." Miss G. L. Elles, "The Bala Country: its Structure and Rock-Succession."

Metals, Institute of, Institution of Mechanical Engineers, Storey's Gate, S.W. 1, 10.30 a.m. 1. Professor H. C. H. Carpenter and Miss C. F. Elam, "Stages in the Re-Crystallisation of Aluminium Sheet on Heating, with a Note on the Birth of Crystals in Strained Metals and Alloys." 2. Mr. P. H. Brace, "Some Notes on Calcium." 2.30 p.m. 1. Professor C. A. Edwards and A. M. Herbert, "Plastic Deformation of some Copper Alloys at Elevated Temperatures." 2. Messrs. H. Moore and S. Beckinsale, "The Action of Reducing Gases on Heated Copper."

Literature, Royal Society of, 2, Bloomsbury Square, W.C. 1., 5.15 p.m. Professor Walter de la Mare, "Imaginative Prose."

THURSDAY, MARCH 10 .. Fine Art Trade Guild, at the ROYAL SOCIETY OF ARTS John Street, Adelphi, W.C., 7.30 p.m.

Royal Society, Burlington House, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, W. 8.30 p.m.

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Dr. H. Rees, "Chinese Fiction."

Metals, Institute of, at Institution of Mechanical Engineers, Storey's Gate, S.W. 1., 10.30 a.m. Annual General Meeting (continued). 1. Messrs H. Moore, S. Beckinsale and C. E. Mallinson, "The Season Cracking of Brass and other Copper Alloys." 2. Dr. J. L. Haughton, "The Constitution of the Alloys of Copper with Tin." Parts III. and IV.

Royal Institution, Albemarle Street, W., 3 p.m. Dr. G. C. Simpson, "The Meteorology of the Antarctic." (Lecture I.)

Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m. 1. Professor H. F. Newall, "The Story of a New Star." 2. Mr. T. F. Connolly, "Note on a Handy Form of Measuring Microscope."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Professor E. Wilson, "Feebly Magnetic Materials." Lecture III. Practical Applications.

Historical Society, 22, Russell Square, W.C., 5 p.m. Mr. A. H. Thomas, "Illustrations of the Mediæval History of London, from the Guildhall Records."

Mathematical Society, Burlington House, W., 5 p.m.

FRIDAY, MARCH 11 .. London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4 p.m. Annual Meeting. 4.30 p.m. Mr. I. G. Gibbon, "Zoning and Town Planning."

Royal Institution, Albemarle Street, W., 9 p.m. Dr. J. Freeman, "Medical Idiosyncracies."

Civil Engineers, Institution of, Great George Street, S.W., 8 p.m. (Students' Meeting.)

Electrical Engineers, Institution of, King's College, Strand, W.C. 2., 6.30 p.m. (Students' Meeting.) Mr. J. A. Broughall, "Some Recent Developments in Converting Machinery for Small Substations.

Engineers and Shipbuilders, North-East Coast Institution of, at Literary and Philosophical Society, Newcastle-upon-Tyne, 7.30 p.m. Mr. A. L. Ayre, "Organisation for Ship Production."

Astronomical Society, Burlington House, 5 p.m.

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

SATURDAY MARCH 12 .. Engineers and Shipbuilders, North-East Coast Institution of, Newcastle-upon-Tyne, 6.30 p.m. (Graduate Section). Professor G. Thompson, "Theory of Probability."

Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Electricity and Matter." (Lecture II.)

Chromatics, International College of, Caxton Hall, Westminster, S.W., 3.15 p.m. Professor H. M. Léon, "The Story of the Discovery of Colour Blindness."

Journal of the Royal Society of Arts.

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FRIDAY, MARCH 11, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 14th, at 8 p.m. (Cantor Lecture.) MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." (Lecture II.)

WEDNESDAY, MARCH 16th, at 8 p.m. (Ordinary Meeting.) CHARLES AINSWORTH MITCHELL, M.A., F.I.C., "Science and the Investigation of Crime." The Right Hon Lord Justice Atkin in the chair.

CANTOR LECTURE.

On Monday evening, March 7th, MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc., delivered the first of his course of lectures on "X-Rays and their Industrial Applications."

The lectures will be published in the *Journal* during the summer recess.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 2nd, 1921; LORD HENRY CAVENDISH BENTINCK, M.P., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Adams, Charles Hubert, B.Sc., A.M.I.A.E., Shinfield, Berkshire.
Gaul, James, Jamaica, B.W. Indies.
Lynch, Hon. James Challenor, O.B.E., LL.M., Barbados, B.W. Indies.
Macnab, Henry Edwin, London.
Marreco, Geoffrey Algernon Freire, Woking, Surrey.
Phillips, Edward George, London.

The following Candidates were balloted for and duly elected Fellows of the Society —

Dyson, William, Rotherham.
Garrett, J. D., London.
Hart, T. C., B.A., Dominica, B.W.I.

A paper on "The Re-Education of the Disabled" was read by Captain J. Manclark Hollis, Secretary to the Village Centres Council.

The paper and discussion will be published in a subsequent number of the *Journal*.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1921 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 26th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce, and has been awarded as follows in previous years:—

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1869, Baron Justus von Liebig.
1870, Vicomte Ferdinand de Lesseps, Hon. G.C.S.I.
1871, Sir Henry Cole, K.C.B.
1872, Sir Henry Bessemer, F.R.S.
1873, Michel Eugène Chevreul.
1874, Sir C. W. Siemens, D.C.L., F.R.S.
1875, Michel Chevalier.
1876, Sir George B. Airy, K.C.B., F.R.S.
1877, Jean Baptiste Dumas.
1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S.
1879, Sir William Thomson (afterwards Lord Kelvin), O.M., LL.D., D.C.L., F.R.S.
1880, James Prescott Joule, LL.D., D.C.L., F.R.S.
1881, Professor August Wilhelm Hofmann, M.D., LL.D., F.R.S.
1882, Louis Pasteur.
1883, Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1884, Captain James Buchanan Eads.
1885, Sir Henry Doulton.

1886, Samuel Cunliffe Lister (afterwards Lord Masham).
1887, Her Majesty Queen Victoria.
1888, Professor Hermann Louis Helmholtz.
1889, John Percy, LL.D., F.R.S.
1890, Sir William Henry Perkin, F.R.S.
1891, Sir Frederick Abel, Bt., G.C.V.O., K.C.B., D.C.L., D.Sc., F.R.S.
1892, Thomas Alva Edison.
1893, Sir John Bennet Lawes, Bt., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.
1894, Sir Joseph (afterwards Lord) Lister, F.R.S.
1895, Sir Isaac Lowthian Bell, Bt., F.R.S.
1896, Professor David Edward Hughes, F.R.S.
1897, George James Symons, F.R.S.
1898, Professor Robert Wilhelm Bunsen, M.D.
1899, Sir William Crookes, O.M., F.R.S.
1900, Henry Wilde, F.R.S.
1901, His Majesty King Edward VII.
1902, Professor Alexander Graham Bell.
1903, Sir Charles Augustus Hartley, K.C.M.G.
1904, Walter Crane.
1905, Lord Rayleigh, O.M., D.C.L., Sc.D., F.R.S.
1906, Sir Joseph Wilson Swan, M.A., D.Sc., F.R.S.
1907, The Earl of Cromer, O.M., G.C.B., G.C.M.G., K.C.S.I., C.I.E.
1908, Sir James Dewar, M.A., D.Sc., LL.D., F.R.S.
1909, Sir Andrew Noble, K.C.B., D.Sc., D.C.L., F.R.S.
1910, Madame Curie.
1911, The Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., F.R.S.
1912, The Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., G.C.V.O., LL.D., D.C.L., F.R.S.
1913, His Majesty King George V.
1914, Chevalier Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.
1915, Sir Joseph John Thomson, O.M., D.Sc., LL.D., F.R.S.
1916, Professor Elias Metchnikoff.
1917, Orville Wright.
1918, Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S.
1919, Sir Oliver Joseph Lodge, D.Sc., LL.D., F.R.S.
1920, Professor Albert Abraham Michelson, For. Member, R.S.

CASES FOR JOURNALS.

At the request of several Fellows of the Society, cases have been made for keeping the current numbers of the *Journal*. They are in red buckram, and will hold the issue, for a complete year. They may be obtained post free, for 7*s*. 6*d*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

EXTRA MEETING.

Tuesday, February 8th, 1921.

Mr. G. J. Wardle, C.H., late Parliamentary Secretary, Ministry of Labour, in the Chair.

The following paper was read:—

SOME OF THE PROBLEMS OF UNEMPLOYMENT.

By Ed. C. de Segundo, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E.

The world is confronted to-day with many problems of unprecedented complexity, and perhaps the one calling most insistently for solution is the problem of unemployment, not only because of the suffering attendant upon abnormal unemployment, but because this indicates a set-back in our recovery from the effects of the War, and also because there seems little doubt that the extremists, under the guise of advancing the interests of labour, are exploiting unemployment for the purpose of fostering their revolutionary campaign. It is perhaps needless to say that the true labour movement is *not* revolutionary.

The problem of unemployment did not arise yesterday nor yet the day before. Twenty-three centuries before Christ the Assyrian Hammurabi wrestled with the self-same industrial problems we are experiencing to-day, and drew up a code regulating the relations between master and man, and fixing a minimum wage for artisans of all classes. Clearly, Hammurabi did not permanently solve the problem, and humanity has gone on ever since unsuccessfully trying to substitute rules and regulations, Acts of Parliament, and "isms" and "ologies" galore for the only real panacea for social ills—the observance of the golden rule which Emerson merely paraphrased when he wrote: "Every man takes care that his neighbour shall not cheat him. But a day comes when he begins to take care that he does not cheat his neighbour. Then all goes well." If masters and men took care not to cheat each other, the occupation of the agitator would be gone. And yet, this is not the whole story. A difficulty—in some cases an insuperable difficulty—arises when the increase of the population outstrips the means of subsistence. This brings us into deep waters, which I dare not even attempt to plumb to-night. But

this aspect of the problem must be faced, and that in the not far-distant future.

Introductory Remarks.

The world situation to-day in regard to employment is a gigantic paradox. There can be no question whatsoever of the immense amount of work waiting to be done, work of reparation of property, work of rehabilitation of commercial and industrial relations, and work of reorganising the destroyed and dislocated means of transport and communication between nations. Nevertheless, unemployment threatens to increase, not only in Great Britain, but throughout the whole world, except in Germany.* This War has brought to light in a way that nothing else could have done, how completely interdependent individuals, communities and nations have become. No country in the civilised world can to-day be said to be self-sufficing or self-supporting. Every country is vitally in need of commodities it cannot produce, which it must, therefore, obtain from beyond the confines of its own territory. For a couple of generations during the last century Great Britain enjoyed an unexampled period of prosperity, and for a time became the strong-box of Europe and the workshop of the world, owing chiefly to its easily and cheaply worked supplies of coal and iron ore. This state of affairs has long since ceased to exist, although London continued to be the financial centre of the world, and Great Britain became, so to speak, the world's exchange, for England was a creditor country up to the outbreak of war, while practically every other country was debtor to England. But this state of affairs also is a thing of the past. The financial strain of conducting our military and naval operations and of financing some of our Allies has necessitated the realisation of a large proportion of our investments abroad, in addition to which we have contracted a considerable debt to the United States.

During the War commodities had to be produced irrespective of cost. The Allies won the War, and thereupon a large number of us thought that there would be an immediate commencement of a period of great business activity. Those who had been able to command practically any price for their services during the War expected to continue to receive remuneration on a similar scale. This was not unnatural, it was merely human nature—but it was not common-sense. In view of the economic condition to which the Central Empires had reduced themselves, the immediate payment of an appropriate indemnity *in cash* was impossible. It is strange how wide-spread is the idea that *any* amount of cash can be got together if only sufficient pressure be applied. Few know that in pre-war days the total amount of bullion in the world was insufficient to liquidate more than a mere fraction of the world's indebtedness; the proportion to-day would be microscopic. International financial relations are based upon *credit*, and a nation's credit is a function of its developed and undeveloped natural resources; of its gold reserve; and of its foreign trade balance.

Misuse of the Terms "Capital" and "Labour."

Most of us still consider "capital" to be synonymous with cash or its equivalent, and "labour" as applying only to manual work, and assume that there is a fundamental antagonism between them. A right perception of the meaning of capital and labour reveals the fact that neither is, in itself, capable of achieving any useful purpose, and that what people *really* mean when making use of these terms is the *employment* of capital or the *employment* of labour. Thus the element of directive ability is unconsciously implied just as in speaking of a "force," the existence of somebody or something that gives the force magnitude and direction is necessarily involved, although this is not always realised. Capital and labour are, in themselves, inert (though necessary) factors in the production of wealth and the vitalising factor is directive ability. This simple truth was admirably exemplified recently, when the workmen seized the factories of the Fiat Company in Italy, and a few weeks afterwards had to beg the so-called "capitalist" element to take charge again.

"Capital" and "Labour" are, in last analysis, not *commodities*, but are the outcome of different manifestations of the intellectual faculties directed by the will. Directive ability, whether applied to one's own form of activity or to that of some other person, is a form of capital. The humblest labourer who merely carries out instructions must use his brains, and, in this sense, belongs to what is so loosely

* See the General Report of the Industrial and Economic Situation in Germany, 1921 [Cmd 1114], p. 62.

termed the "capitalist" class, as much as the man who controls the largest amount of cash or credit.

The mere possession of cash does not bring with it the ability usefully to employ the cash. We all know the adage "a fool and his money are soon parted," and also the North Country aphorism, "It only takes three generations from clogs to clogs."

The Proximate Causes of Present-Day Unemployment.

The proximate cause of unemployment in this country to-day is unquestionably the simple fact that the price at which commodities can be remuneratively sold has risen above the purchasing power of a large number of consumers. This has come about owing to the neglect on the part of the producer class of a rudimentary principle of economics, namely, that there is a limiting relation between the rate of earning of the producer and that of the purchaser, and that there is a limit to the extent to which the temporary necessities of others can be remuneratively exploited. For every seller there must be a buyer; there is no incentive to produce if no remunerative market exist for the product. Thus increase of production will not, of itself, avail effectively to reduce unemployment or to relieve our financial embarrassments, unless the commodities produced respond to the demand and be offered at a price that will successfully compete with that at which other producers offer them.

This applies not only to our domestic trade (whereby the importation from abroad of articles we can ourselves produce can be reduced and the adverse trade balance diminished), but to our export trade, which helps to pay for those commodities we need, but cannot ourselves produce.

To take a concrete example: Great Britain has to import a large quantity of foodstuffs from foreign countries, but it can only continue to do so as long as it produces and ships to these countries commodities such countries desire at a price they are willing to pay. If foreign countries cease to desire what Great Britain makes, or if they can obtain what they desire more cheaply elsewhere, then Great Britain will starve, and no juggling with the exchanges or other artificial expedient the wit of man may devise will alter this. There is no possible escape from the consequences attending an increase of the population beyond the means of subsistence. The maintenance of a working relation between these two things is a condition *sine quâ non* of our persistence as a nation.

The consumer must also be a producer and must find a market for his products, otherwise his power to consume will wane. The productivity of Russia, of Austria, of Hungary, and of other European countries is greatly diminished; their power to purchase is correspondingly reduced; they cannot buy the goods they would like to have from us (or from others); we consequently suffer from the absence of the markets which existed before the War for certain of our products. Money must be earned before it can be spent in wages or anything else. Most of us, from Ministers at the Treasury to Labour Leaders, seem to ignore this simple fact. On the one hand, labour has abused the power conferred by the organisation it has legitimately brought about, and in regard to wage increase has held the unorganised portion of the community to ransom time and again. On the other hand, the Government has abused the authority vested in it by the country, and has launched out into extravagant projects—no doubt with the most laudable intentions—without appearing to be concerned whether or not the country is able to foot the bill.

Both parties have exhibited a lack of a proper sense of proportion.

Both parties have relied upon the defenceless position of the unorganised taxpayers.

But *naturam expellas furca, tamen usque recurret.* The continued drawing of water from a cistern at a greater rate than that at which the supply pipe delivers, naturally results in the exhaustion of the contents of the cistern. Moreover, the "factor of dispensability" has come into operation: the vast majority of us are restricting our commitments to bare necessities; demand is lowered in an increasing proportion; manufacturers cannot dispose of their products except at a loss; production is curtailed, or stopped; and workers of all grades are thrown out of employment.

One of the governing factors in the present industrial situation in this country is the effect of the Excess Profits Duty.

As a war-time measure, when owing to the impossibility of accurately estimating costs and values, gigantic profits were being made by Government-controlled establishments financed, very often, with Govern-

ment money, it served the useful purpose of a rough and ready means of adjusting, in some degree, the great disproportion between real cost of production and price paid by the country for the necessaries of war. The continuance of this tax was unsound commercially, shortsighted financially, and simply disastrous industrially speaking. In 1919 the tax was reduced and its abolition in 1920 was confidently anticipated, instead of which it was increased from 40% to 60%, in spite of the most strenuous endeavours on the part of eminent and respected leaders of industry to convince the Government of its error. The commercial risk of carrying on business was immeasurably increased. All plans for the extension of plant and machinery, all schemes for expansion of business relationships, all initiative and enterprise received a death-blow.

The sequence of events has been but the natural operation of cause and effect. The return on capital invested in industrial undertakings became entirely problematic—the only certainty being that it would be reduced. The uncertainty respecting the demands of organised labour and the seemingly extravagant expenditure by the Government accentuated the already sufficiently precarious position of the investor. Many thought it better to have their money on deposit at their bank than to leave it invested in shares of public companies which were an easy prey to the predatory attacks of ill-considered financial legislation. In addition there has been much forced liquidation to provide the wherewithal to pay income tax, and the resulting depreciation in the values of Stock Exchange securities since January, 1920, is calculated to have been at one time about £500,000,000. Owing to the unstable economic position, and to the increasing lack of confidence in the power of the Government to deal with the situation, the savings of the thrifty, which under normal conditions form the main source of financial support for the development of new industries or for the expansion of existing industries, are not available for these purposes to-day, and one of the chief factors in the stabilization of employment is, therefore, absent. Judging by the aggregate Bank deposits in the United Kingdom, these accumulated savings must amount to-day to a very large sum indeed. The withdrawal of credit from trade and industry; the high Bank rate; the unprecedentedly severe fall in the values of commodities during the last months of 1920 and the crushing burden of present-day taxation, are strangling industrial activity and are conducing, as a natural result, to the increase of unemployment, which—leaving out the sentimental aspect—is of the gravest import to the economic position of the country.

It is becoming more and more evident that the net amount the Excess Profit Duty will yield will not be anything like the sum anticipated. Owing to the shrinkage of trade, the Government will have to refund large amounts during the next two years, and thus not only has the Excess Profits Duty stricken unto death the goose that lays the golden eggs, but a considerable proportion of the golden eggs will become unavailable for the purposes for which the goose was killed.

Four days ago the Chancellor of the Exchequer, impelled by the extreme gravity of the situation, announced that the provisions of this year's Budget would include the abolition of the Excess Profits Duty.

If this announcement had been made a few months ago, a good deal of the unemployment existing to-day could probably have been avoided.

Attitude of Labour.

A word now as to the attitude adopted by "Labour." My experience of the British working man coincides with that expressed not so long ago by Sir Alfred Yarrow. He said that the British working man, speaking generally, had a fund of sound common-sense and had his heart in the right place, but he had one defect, namely, that he could not see far enough ahead. With all respect to our friends the Labour Leaders, can *they* see much further ahead than the average working man? and if they do, can they carry their men with them? Now, whatever may be the nature of the "secret diplomatic action" among Labour Leaders, is not the attitude of some of them—so far as the unorganised portion of the community is concerned—very much of this order: "We want so and so, and we are going to have it, and if you don't give it to us we will stop your railways, and your coal, and your food." Does this encourage the brains of the community to undertake the organisation of new enterprises tending to create further employment?

Lightning strikes and other forms of "direct action" are not exactly calculated to promote friendly relations between employer and employed, or to encourage the initiation of new undertakings which, perforce, involve a high degree of risk until proved to be commercially successful. I have looked into many schemes for promoting the interests of the "working classes," but I do not recollect a single instance in which any account is taken of the risks run by those who devote their brains and their money to the *development* of existing industries, or to the *creation* of new industries, upon both of which forms of activity an increase in the employment of the workers depends. During the period (and it may be years) required to work out some new invention, or commercially to test the efficiency of some new process, as applied to an existing industry, the workers receive their wages regularly and have no responsibilities, whereas those who supply the money during the experimental period and those who have to solve the technical and commercial problems involved, bear the whole risk and the whole burden of worry and anxiety. In the case of failure, a dead loss is incurred; in the case of partial success, a but meagre return is yielded; in the case of complete success, surely those who have taken the entire risk are entitled, in common justice, to a greater share of the proceeds than those who have borne neither risk nor responsibility.

Only those who have had personal experience of what is involved in bringing a new idea to fruition, in the teeth of opposition, with faint support, hampered and discouraged by the deep-rooted prejudice almost invariably exhibited against "anything new," can estimate at its true value the work of the pioneer in any branch of science or industry. Under subsisting conditions of taxation, and in view of the wholly indeterminable character of the demands of organised labour, there is no inducement whatever to do more than to endeavour to keep one's business alive and avoid the Bankruptcy Court.

It is not often realised that a tax of 6s. in the £ on *earned* income is virtually the equivalent of *two days' forced labour per week*.

The avowed object of many of the Trade Unions seems to be *not* to stimulate a desire to excel among the members, but, on the contrary, to discourage any member from working more efficiently than the least efficient of the members, to the end that the greatest number of men may have to be employed to do a given amount of work. Again, we have the natural sequence of cause and effect, the performance per man steadily diminishes, both as regards quality and quantity. Wages remaining at the same level, the value yielded per unit of wages sinks, cost of production rises, competition in the international market becomes more and more difficult, and it does not require a Solomon to foresee the inevitable result—the ruin of our foreign trade, the decline of trade and industry and eventual national bankruptcy.

Encouragement of Initiative in Industry and Protection of Key Industries.

History teaches us that there is the analogy of birth, adolescence, and decay in industrial processes.

As time goes on, conditions alter and existing processes become obsolete, and in proportion to the extent we keep abreast of the times so shall we maintain our position in the commercial world, and maintain and increase the occasions for the employment of labour. A suitable measure of relief from taxation in respect of expenditure on scientific and experimental research would greatly stimulate effort in the direction of improving existing methods and of turning to account the by-products and waste products of industry. This could not but benefit the community at large, and, moreover, the adoption of measures to this end would only be on a par with the grant to an inventor of the monopoly of his invention for a period of years in order to afford a proper opportunity for the establishment of such invention on a firm commercial footing.

Any industry adjudged to be an essential (or key) industry should—it would appear—be *permanently* protected from attack by "dumping" or other form of foreign competition.

Experiments in Social Reform.

These are, no doubt, very interesting times, historically speaking, but the making of history is not always an easy or a pleasant process. We are making gigantic experiments on an unprecedented scale in what is termed "social reform." That social

conditions need reform I do not question for one moment. They always have, and they always will, because of the imperfections of human nature. Socialism is a beautiful ideal, a consummation devoutly to be hoped, but the argument for Socialism is a *petitio principii*; it presupposes the existence of that which it seeks to bring about, because true socialism necessarily involves perfect humanity, and if humanity were perfect there would be no call for socialism.

History records many attempts to put socialism into practice. All have failed. The explanation usually given is that they were carried out on too small a scale. Surely the trial has been made on a sufficiently large scale in Russia, and what has been the result? Absolute and complete failure except from the point of view of those who have been astute enough to secure for themselves the power of "directing" the distribution of wealth.

The fact that men *do* rise, and have risen throughout all generations, from poverty to affluence, from obscure to leading positions in every branch of art, science, industry and commerce, indicates clearly enough that our subsisting social system is no *inherent* bar to progress and the achievement of success by those born in humble circumstances.

The exercise of intelligence, the ability to form a reasoned judgment, the power to organise, perseverance, prudence, and a hundred other attributes without which our social and industrial life would not subsist for one moment, are incapable of being weighed or measured, or valued in money; nor can they be coerced by any physical agency. They are possessed in widely differing degrees by members of all classes. There is good and evil in every one of us, and no class can claim preeminence in brains or virtue. There is a natural—and inevitable—tendency for human beings to become automatically segregated into classes irrespective of the accidents of birth or convention, just as eggs are classified irrespective of the breed of hens that laid them. The "class war," as exploited by certain propagandists, is not only a pernicious and mischievous one, it is also untenable. The members of the so-called "classes" are in a constant state of flux. A bookbinder's assistant becomes a leading light in the scientific world, a railway porter becomes a Minister of the Crown, a peer's son becomes a dock labourer and—ethically speaking—the peer's son may rise and the railway porter fall in the process.

A little reflection should convince us that all men are not equal, physically, mentally, or constitutionally, and that there are no such things as "natural rights."* A member of a civilised community only acquires rights by earning them. To-day we hear too much of rights and privileges and too little of the observance of concomitant duties and responsibilities. Many of us think that it is of the essence of business to obtain something for less than its value—for nothing if possible.

Such men respect the conditions of legal liability and of limited liability, but are not over-much concerned with the unwritten obligations of moral liability, although, paradoxically enough, few of them would hesitate to endorse the opening words of the recent resolution of the Association of British Chambers of Commerce in connection with the resumption of trade with Russia, namely, that the maintenance of good faith and the sanctity of contract are the bases of all human intercourse, whether commercial, political, or social.

Education and the Observance of the Moral Law.

In ultimate analysis, the only thing that will keep us from social disintegration, is the more rigid observance of the moral law. In February, 1919, Mr. W. L. Hichens concluded an interesting paper on "The Wage Problem in Industry" with these words:—"Failure to solve our industrial problems implies moral failure on our part, and it is well to recognise it and to realise that the most profound and exhaustive research will never find a substitute for the moral code which is the mainspring of all human societies."

Lord Askwith, in his profoundly interesting work, "Industrial Problems and Disputes," says:—"If the orderly advance of peaceful development is to be obtained, in place of the surging storms of hatred and strife, there must be more knowledge, so that men should not blindly follow guides who may be blind. . . There must be efforts to improve the comfort of the

*The most completely shattering exposure of the doctrines of Rousseau and of men of his school of thought of which I am aware, is to be found in Huxley's essay "On the natural inequality of man" and on "Natural and Political Rights."

workshop and its surroundings, reduce the monotony of work, and by all possible means obviate the fear of unemployment. . . There must be the desire of common interest partly by the touch of human and personal sympathy, partly by the joint interest of material gain, with the ideal of joint service. It is the *spirit*, not *paper systems*, which alone can prevent war and reduce the reasons for industrial strife.''

But the inculcation of this principle does not occupy a prominent place in our educational system, which is concerned too much with *books* and too little with *things*.

One of the results of our much vaunted—and expensive—system of education has been to bring into existence a large class who have learnt to reason, but have not been taught how to reason correctly.

''This belief in the moralising effects of intellectual culture, flatly contradicted by facts,'' Herbert Spencer told us in 1875, is absurd *a priori*. . . . ''One who should by lessons in Latin hope to give a knowledge of geometry, would be thought fit for an asylum, and yet he would be scarcely more irrational than are those who by discipline of the intellectual faculties expect to produce better feelings.''

The dire consequences of confining education to the development of the rational faculties are shown in the utter preversion of the moral sense of Germany to-day. ''Education,'' said Mr. Ellis Barker, in the ''Nineteenth Century'' three years ago when referring to the Prussian system of education, ''far from enlightening the German nation, has blinded, debased, and dehumanized it.'' Forty-five years ago Cardinal Manning uttered words respecting the future of Germany, which the event has shown to have been truly prophetic. He said:— ''A fatal extinction of supernatural light, the aberration of false philosophy, the inflation of false science and the pride of unbelief, are preparing Germany for an overthrow or for suicide.''

Would it not be the part of wisdom for us to take warning?

The Importance of the Study of Economics.

Economics has been called ''the dismal science.'' Dismal or not, it is a science with which we shall have to occupy ourselves in the future to a vastly greater extent than we have done in the past. We must take the growth and development of other countries into practical account. It cannot be too insistently dinned into the ears of every man, woman and child in Great Britain that we are dependent upon foreign countries for the greater part of the necessaries of life, that we can only continue to obtain these necessaries of life by giving these countries at least the equivalent in value of what we get from them and that this must be achieved by appropriate industrial effort and by the maintenance of an efficient land and sea transport system. A few days ago, Mr. Arthur W. Kiddy, in an illuminating lecture on ''Our foreign trade in relation to the position of the Exchanges,'' pointed out that ''although for general convenience the system of barter between countries has long since been abandoned, and settlements are effected on a monetary basis, the *principle* of barter remains to-day.'' The failure on the part of employers and employed alike—speaking generally—to *realise* this fact is the only reasonable explanation of the continuance of the internecine strife which has characterised the history of our industry and trade during the last few years. Workers and employers are both to blame, and I am not going to attempt to apportion the blame, but I am going to express the unshakable conviction that nothing of any permanent value will be achieved by violence on either side; that it is *reform* we need, not *revolution*, and that such reform can only be prosecuted with any hope of success by masters and men getting to know each other better, by each studying the necessities and difficulties of the other, and by replacing the policy of ''get—or if need be, *grab*'' by ''help—and if need be, *give*.'' Differences between masters and men can only be satisfactorily settled by discussion between representatives of each side who are sufficiently acquainted with the needs of the other and any endeavours to deal with such questions by academic measures or legislative enactments are foredoomed to failure. I consider myself fortunate in having as Chairman to-night Mr. George Wardle, whose services, as Parliamentary Secretary of the Ministry of Labour, in the cause of industrial peace need no mention from me. Mr. Wardle is also Vice-President of the Industrial League and Council, an association formed in 1915, with the object of bringing master and man into more intimate relationship, and I hope

he will give us some details of this admirable organisation, which has already rendered yeoman service alike to employers and to employed.

Organisation of an Industrial Army.

Assuming that the moral law be recognised alike by masters and men, I cannot see that we have any alternative but to consider that our working classes are just as much a necessary factor in the life of our social organism as the air we breathe is in the life of the individual. Provided every worker, be it one who uses his head or one who uses his hands, recognises that firstly he must qualify as a citizen; secondly, that he is only entitled to remuneration in proportion to the services he renders, and, *thirdly*, that the scale of remuneration is to be based upon the character as well as the extent of his service, a strong analogy seems to exist between such workers as a body, in relation to the maintenance of our industry and commerce, and our Army and Navy in relation to the maintenance of our independent national existence. Our military and naval forces are not always actively engaged; our police are not always arresting delinquents, nor are our firemen continuously putting out fires, but when necessity calls, we expect them to be ready for immediate service. Similarly, in times of active demand for the products of industry more workers will be required than in times when the demand is low. During the period of slack demand the country should recognise that the workers not required for the time being should be maintained and kept occupied in such wise that their efficiency is not impaired so that they may be available for active service in time of need. The country should be prepared to look upon this aggregation of workers as its "industrial army" and to provide for the proper maintenance of any portion of this army during the period when it is not on active service, the means for so doing being provided by some form of insurance to which the Government, workers, and employers should contribute in proportions to be determined—appropriate measures being adopted—it goes without saying—to minimise the abuse of this principle. Further, this industrial army should be drawn from the ranks of *British* working men who have qualified, and remain qualified, in the manner above indicated, and should not be open to alien hordes who have no inherent claim upon Great Britain.

While giving the Labour leaders every credit for good intention and while not underrating the value and importance of constitutionally conducted Trade Unions, there is no question whatsoever that a standard of efficiency, ability and moral character should be fixed by the Trades Union authorities as a condition precedent to membership, and that it should be the responsible duty of the officials of the Union to see that every labourer *is* worthy of the hire they insist upon his receiving, and that his liberty of action as regards the hours he works or the character of the work he does is not interfered with.

Similarly, the attainment of a standard of efficiency, ability and moral character should be a condition precedent to the appointment of any man to any administrative or executive post in industry.

We stand to-day in deadlier peril of our national existence than at any time during the war. We knew *then* what we were fighting against; to-day we are assailed by insidious foes from within, as well as from without; traitors to all that stands for right and reason, enemies alike to capital and labour, because they live among us, take our pay, and yet do not hesitate to advocate—indeed openly advocate—"putting sand in the boilers of locomotive engines, destroying the vital parts, of machines or breaking looms" (I have quoted from a recently-published book entitled "Direct Action"), in attaining their sinister ends. It is needless to say that all respectable members of the labour movement deprecate such methods, and condemn and disown those who resort to them, and it must not be forgotten that Bolshevism was first encouraged and fostered by Germany. We have no natural defences against the perversion of the minds of our less intellectually endowed brethren by the cunningly devised sophistries of such enemies. We can only strain every nerve to expose the real intent of such propagandists and arrest the division of our house against itself by dispersing the atmosphere of mistrust between employer and employed; by actively condemning, and wherever possible suitably punishing, the abuse of confidence in trade and business; by enforcing more strictly the provisions of the law against perjury; and generally by spreading and fostering in the greatest possible measure, and by all available

means, the dissemination of sound healthy moral principle, particularly in the minds of the rising generation.

SUMMARY.

The views expressed in the foregoing lines, may be summarised as follows:—

That the interdependence of all civilised countries renders it impossible to leave out of consideration trade relations with foreign countries in working out any scheme for the mitigation of unemployment in Great Britain.

That increased production will not cause any relief unless commodities are produced of a character and at a price that will—

(a) Reduce our imports from foreign countries.

(b) Enable us successfully to compete with other producers in foreign markets.

That the maintenance of a working relation between the population of any country and the means of subsistence in that country is essential to the persistence of that country's national existence.

That rights and privileges are not natural endowments, but are rightfully enjoyed only in consideration of the discharge of duties and responsibilities.

That "Capital" and "Labour" *in themselves* accomplish nothing, and that it is only by the application of directive ability that they become factors in production.

That the closest co-operation is essential between those who direct the employment of capital and of labour, and those who carry such directions into effect, in order to ensure the re-establishment of our foreign trade, without which our position in the commercial world would be irretrievably lost.

That the home demand be supplied, as far as practicable, by the product of home industry, to the end that the proportion of such commodities now imported from abroad be reduced as much as possible.

That every useful means be adopted, by individual effort and by active propaganda, to ameliorate the relations between employer and employed, and to instruct both classes in the essentials of economics.

That the powers of the Government to involve the country in heavy annual expenditure, without adequate prior consideration, be restricted.

That the observance of the moral law be stimulated by education and by more rigidly enforcing the provisions of the law against breaches thereof.

That proper encouragement be given by suitable legislation to the initiation and development of new industries—particularly those relating to the utilisation of waste or of by-products.

That a new industry, if deemed worthy of support, be protected from foreign competition for a suitable period (just as an inventor whose ideas are deemed worthy of a patent protection is given a monopoly of his invention for a term of years), to the end that a proper opportunity be afforded for such new industry to become strong enough to hold its own against foreign competition.

That all industries adjudged to be essential (or key) industries, be permanently protected in a suitable manner.

That some form of insurance against unemployment—at least, in essential (or key) industries—be adopted, to which workers, employers and the country shall contribute in proportions to be determined, to the end that trade and industry be maintained at the highest possible efficiency.

That such workers, in the aggregate, be regarded as our "industrial army," the size of such "army" being determined by joint action between Trade Unions and, say, the Federation of British Industries, or other organisation representing the employers' interests.

That the attainment and maintenance of a standard of character, skill and efficiency, be a condition of service in the "industrial army."

That undesirable aliens be unconditionally excluded from the "industrial army," and that in all cases preference be given to British-born men and women; and that the provisions of the Aliens' Restriction Bill be rigidly enforced.

That neither strike nor lock-out be resorted to in the event of any disagreement or dispute. All strikes and lock-outs come to an end sooner or later, and nothing is gained, but much is lost, by the cessation of work during the period of negotiations.

DISCUSSION.

THE CHAIRMAN (Mr. George James Wardle, C.H.), in opening the discussion, said that if he had any single complaint to make against the paper, it was that the problems dealing with unemployment had been very lightly touched upon, the author having dealt

with industry in general. He quite agreed that to deal with industry in general was to deal with the question of unemployment; but there was a specific problem of unemployment, and up to the present that problem had not been carefully, sufficiently or properly considered. He would like to remind the audience that up to the present moment Labour had had no hand whatever in the direction or control of industry, and, therefore, the problem of unemployment had been one for the captains of industry; and he wished that such gentlemen had approached it in the spirit in which the author had approached it that night. He would point out that the only provision which had been made for unemployment up to within very recent years had been that made by Labour itself—by the Trade Unions of the country. Nobody else had thought of making any provision, and neither the author nor anybody else, therefore, must be surprised at some of the manifestations which they saw to-day. The solution of unemployment was a very grave national problem, and that solution must be sought and must be found. Up to the present moment no complete solution had been found. The author had stated that he (the Chairman) was a member of the Executive of the Industrial League and Council. What did that League seek to do? It said that, with regard to the problem of unemployment and all other industrial problems, the solution should not be sought alone by either one side or the other. He spoke of "sides," but he thought the sooner the idea was got rid of that there were any sides in the business at all the better. When that idea was dispelled the next step to take was to seek a joint solution of the problems connected with unemployment. If employers and workmen understood their own interests to the full, they would realise that no possible solution could be arrived at which was not a joint solution, and one which they were both determined to bring about.

He had been extremely interested in the paper. He did not think the author quite knew how far he had gone. When he (the Chairman) had been a member of the Labour Party in very active service, that party had been told, when they had brought in their Right to Work Bill in Parliament, that they were undermining the whole constitution of industry and of the country. But what was Mr. de Segundo's real panacea for the problem? It was that there should be an industrial army, and that when that industrial army was not at work it should be paid, just as the policeman, the soldier and the sailor were paid their wages when they were not on active service. That was a revolution in industry. It was a revolution which the Right to Work Bill had sought to put upon the Government. He was not concerned to argue at the moment whether the cost of keeping the industrial army should be put upon the country, the employer or the employed: all he was pointing out was that the author had admitted in the paper the principle that if the worker registered himself in the industrial army he should be provided with some means of keeping himself alive when he was not on active service. The fear of unemployment, and actual unemployment, was a nightmare to the working classes. There was nothing they feared more. He was quite willing to agree that when people were in work they should provide for a rainy day, but he wondered if all capitalists did that. The margin in the one case and in the other was very different, and it was that margin which made all the difference in the world. Even supposing it were possible for each person by great thrift to make provision for a rainy day, that was not a proper and reasonable solution of the problem. There must be a solution found for the problem of unemployment, which he looked upon as the most grave industrial problem of the time. He would never believe it was beyond the possibilities of statesmanship and common-sense and industrial efficiency in this country to find such a solution. He believed that the solution would be found partly in the idea of insurance, and partly through a reorganisation of our industrial system: but he repeated that, so far as he was concerned, he thought no solution was possible unless and until employers and employed were willing to meet together and discuss the problem around a table and work together. Therefore it was that he welcomed the fact that the Royal Society of Arts had opened its doors to the discussion of the problem, and he expressed the earnest hope that the meeting would re-echo through the country and would force everybody to see that somehow or another a solution to the problem which threatened the nation at the present time must be found.

Mr. John Baker said he was sorry that the author had not approached the problem in a spirit that was going to tend towards a solution of it, but had approached it in that very spirit which he condemned in the workers. It was stated in the paper that during the war period Labour, meaning organised Labour, had abused its power in regard to wages. That statement was absolutely and emphatically untrue. No broad mass of the principal industries of this country since 1914 had had a single advance in wages which had not had to be submitted to arbitration, and which had not had to be based upon the argument of the increased cost of living. If that statement was true Labour had not used its power at all, much less had it abused it. In the early days of the war, Labour had withdrawn from the employers every claim that it made for advances of wages, every claim for reduction of hours, and every claim for improvement of conditions, and it had urged upon the Government that they should control industry and keep prices down. It was the

only section of the community that had taken up that attitude. But prices went up, and wages followed prices. The general earnings of the workers of this country had been reduced by one million pounds per month within two months of the outbreak of war, and had not recovered until after the middle of 1915. Prices of foodstuffs in the country had increased by 16 per cent. within eight days of the outbreak of war. Men could not be expected to live on starvation wages if the prices of goods were doubled; it was not a reasonable proposition. Then men asked for advances. They waited for nine months and did not get them. The Government then passed a Bill which instituted tribunals whereby it was impossible for one workman to leave one works and go to another without the permission of that tribunal. Yet the author talked about Labour using its power. It was nonsense. After that a commission had been sent throughout the country, which reported to the Government that undoubtedly the ever increasing prices were the chief cause of the unrest existing in the country at that time, and the Government set up an Industrial Court. Before that Industrial Court no other argument weighed than the increased cost of living. It was stated that Labour had increased the margin between wages and the increase in the cost of living. He suggested that the author had not made a single enquiry as to the truth of that statement, and had not given a single figure to bear out its correctness. The statement was not true. The average wage of the members of the Amalgamated Society of Engineers had not increased at the same rate as the cost of living had increased. Those men in a skilled industry were in a worse economic position now than they had been in 1913. There was the outstanding fact that the wealth of this country from 1914 to 1920 had almost doubled. Dr. Stamp's own figures showed that the wealth production of 1914 was £2,100,000,000, and that the 1920 figure could not exceed £4,000,000,000; he believed it was more than £3,900,000,000, and in all probability the proper estimate was £3,950,000,000. The wealth of the country was increasing by leaps and bounds, but the wages of the workers had to stay where they were. Why was that so? He himself was a worker, and he was going to see to it that the wages of the workers of this country were not going to stay where they were in the face of such an increased wealth productivity. The wages of the iron and steel workers were regulated by Boards of Arbitration. The wages followed the selling price of the product. The wages had increased about 200 per cent., but prices had increased 400 per cent. The author, and gentlemen who took his view, were up against the awkward predicament that they had to explain how 200 per cent. on one item of cost was going to increase the total cost by 400 per cent. There was some other body outside the workers which was using its power.

Professor John A. Todd said he did not agree with the author in his explanation of the immediate causes of the present trade slump. The author put it down mainly to the fact that consumers had found themselves up against a level of prices which they simply could not pay. It had been his (the speaker's) business for the last two years to watch for the slump, and it seemed to him that what had happened was that up till 12 months ago there had been a very distinct tendency towards improved trade, increased demand and rising prices. Then all of a sudden there occurred a complete change. The cause of it had been finance—a change in the financial atmosphere of the country. The attitude of the consumers came later. The consumers had been buying as fast as they knew how, and, while they had grumbled at the prices, they had been prepared to go on buying a good deal longer; but what had happened was that a great cry arose of deflation and falling prices, and the consumers said: "If prices are going to fall we will wait until they do." The consumers' strike occurred after the beginning of the fall of prices. It had been the result of the deflation talk. It had not been the cause of the first beginning of the fall of prices, but the result. That had had a very peculiar effect, and he thought most people who were watching conditions at the present moment would be bound to admit that there was some truth in it. What had happened was that there had been a tendency towards a fall in prices, a tendency for the consumers to hold back and refuse to buy until prices came down, and also a tendency for the wholesalers and the manufacturers to say, "We will bring prices down as soon as we have got rid of our stocks." The consumers then said, "We will buy your stocks as soon as prices come down," and there had been a deadlock which had lasted for nine months, until it had been broken in the textile trade at the sales in the previous month. That deadlock had been the cause of unemployment. There had not been any real reason why there should have been that unemployment. It had been more a financial deadlock, as well as a political and foreign exchange deadlock, than a real state of affairs that should have produced unemployment. There had been no glut of the world's markets, and there had been no over production. The world was still very short of goods of all kinds. There were men anxious and willing and able to produce those goods. The producer was walking the street looking for a job, and the would-be consumers were looking for goods, and they could not get them or could not get the money to pay for them. There was something deadly wrong in the whole system. Personally, he thought that many of the working classes were probably better informed on economic questions than were the masters. There was one thing which a good many of them could not have failed to notice just lately, namely, that there was only one

commodity in the world that had gone up in price substantially in the last nine months, and that was money. Everything else had gone down. One could not help feeling that while unemployment was the nightmare of the working classes, it was the opportunity of the employers. He would not say that employers in this country had taken advantage of this opportunity, but he had very grave suspicions that in America employers had done so. Of course there were many things to be said on the other side. For instance, to take Mr. Baker's argument that because the wealth of this country had increased during the war from £2,200,000,000 to about £4,000,000,000, therefore the working classes should get higher wages; that was simply ignoring the application of Mr. Baker's own argument. The increased wealth was in nominal prices. If one deducted the rise of prices and put it back to the old level of prices, the result was that the country was no better off than it was before the war. He did not believe that there was any one thing that would cure the whole problem. He had great doubts about the author's industrial army. He did not believe the country could afford it. He did not believe the country could escape the obvious abuses of such a system, and he thought it would lead to very great difficulties if the suggestion was adopted. What he did plead for, quite apart from class interest, was a much more sympathetic attitude towards Labour questions from people of other classes. Was it very absurd that in big factories with big capital and big labour forces, some of the workmen should be put on the directorate? Personally, he did not believe they would do very much good; he did not believe they would represent the working class view very much better than they did at the present time, but he did believe they would learn a very great deal. A working man put on as a director would find out how little he knew about the difficulties and the risks and the serious responsibilities of being a big employer of labour. A little mutual knowledge like that would go far further towards producing a friendly settlement of the question of unemployment than almost anything else which could be imagined.

The Right Hon. Lord Askwith, K.C.B., K.C., D.C.L., remarked that all that the author had said showed there was no absolutely uncontroversial form of settlement, nor was there any one form of settlement, of the problem of unemployment; that the cure for unemployment could not be got by a wave of the hand, nor could it be got in a sudden moment. It was a question which required enormous study and enormous co-operation between people in order to get at the best solution with regard to different people, different trades, and, he might almost say in many cases, different individuals. Human nature was not all of one kind, and similar medicines, even for the same kind of disease, very often affected patients in different ways. He had in other writings indicated with much diffidence that some of the points which appeared to be most important in the matter were education, forms of insurance, and mutual co-operation between employers and employed. With regard to unemployment generally in different trades, he had over and over again stated his view that the principle to aim at was that each trade or group of trades ought to try to find its own solution. The author had led up finally to a sort of army of industry, which was to be entered by education, and guided by a moral code. That was a very nice prospect to look forward to, but he thought, even if it were accomplished, it was a matter which would take a considerable time, and that it was not an immediate prospect at the present moment. He agreed that perhaps the present unemployment was to a certain extent unexpected. It was to be hoped that it was also to a certain extent transitory. But it had come, and it showed the importance of discussing the matter in times of better prosperity, with all our brains and power, in order to find a solution of the difficulty, so that panic-stricken measures should not be taken when the sudden emergency arose.

The Rt. Hon. G. H. Roberts, M.P., remarked that if he had found the paper lacking in a great many details, he also had to confess that much of the discussion which had ensued had failed to give him much enlightenment on the great problem of unemployment. It appeared to him that it was no good indulging in recriminations as between class and class. The first question he would like to be confronted was: was there any solution of the problem? He ventured to reply—although he might be misunderstood—that there was no such thing known as an absolute solution of the unemployment problem, because, after all, the industries of this country and their relation to the industries of the world were so complex and intricate that he could not even imagine it possible to organise them so perfectly at home and abroad as to ensure even to every willing worker fifty weeks' work every year. Therefore, he thought it had to be recognised that there would be periods of depression from time to time, whatever was done. The present problem was unprecedented in history. The world was crying for goods, and Labour was anxious to exercise itself in the manufacture of goods; but it was a very remarkable thing that the world stopped buying, not because it was satiated with goods, but because the price of those goods had reached a point where there was a revolt, and not an actual lack of purchasing power. It was a revolt of the consumers of the world against the point to which prices had been forced. It had to be recognised that if employment was to be found for our people in the future there must be markets, and those markets

would only be open to us if the prices of the goods we had to sell compared favourably with those of our competitors. If we were unable to produce on equal terms with our competitors then we would fail to sell, and the unemployment problem would grow in extent, not according to the will and caprice of the employers, and workmen would be compelled to suffer an all-round reduction of wages, not because a wicked body of men called capitalists had met together and had decided on a conspiracy, but because of the sheer economic fact that for some cause or another—either inefficiency on the part of the capitalist or lack of endeavour on the part of the workman—we were unable to produce goods at a price which would compete with the prices of our competitors. That was a fact which employer and workman alike ought to consider. Great Britain more than any other country in the world was dependent on foreign trade. He was not advocating any system of tariffs, but merely that it was incumbent upon the employers and workers in every industry to come together and study the conditions of their industries, and to ascertain why it was that foreign competition was able to cut them out in the markets of the world.

Mr. A. E. Parnacott said so far as the propaganda of the agitator was concerned, the antidote for that was counter-propaganda. It seemed to be a fact that the well-intentioned agitators, as they got fuller knowledge of the subject, departed from the Labour movement and went into other spheres either as servants of the Government or in other directions, and it seemed to him that such men would be very valuable in carrying on counter-propaganda. He considered that one way of getting over many of the difficulties in connection with Labour at the present time was a profit-sharing scheme.

Mr. C. W. Gibson remarked that he was an official of the General Labourers' Union, and would not have taken part in the discussion had it not been that one of the things which seemed to have been insisted upon that night was that there must be confidence between employers and employed if the problem of unemployment was going to be solved. He took it that "confidence" implied that both sides were ready to play the game. One of the previous speakers had said that he had a suspicion that in the United States employers were deliberately taking advantage of the present unemployment in order to reduce wages, but that the employers of this country were not doing so. That had not been his (the speaker's) experience. Within the last fortnight he had had three occasions to interview employers on that very question. The employers had not said "We want to discuss the question of reducing our labour costs with you," but they had merely put up a notice that after such-and-such a date wages would be reduced by so much. That kind of thing naturally introduced a great deal of dissatisfaction and trouble. He agreed with Mr. Roberts that there was no one solution for the problem of unemployment. He believed that, under the best and most ideally organised system of society, some people would be out of work, but those people had to be provided for. But there was a vast difference between that and the enormous number of men and women who were now walking about the streets unemployed. He knew from his own knowledge that there were hundreds of men who would work at any job at any rate of wages which was offered to them. He had been told by one employer the previous week—an employer with whom there was a written agreement that the rate of wage should be £4 5*s*. 0*d*. a week—that a man with a wife and six children had come to him and had offered to take the job at 30*s*. a week. He (the speaker) could quite understand the man's attitude, but there was the fact that the men in that particular trade, for the sake of their own wives and families, could not allow that man to start at 30*s*. a week. Unfortunately, however, there were some employers who would immediately take that man on at that rate of wage. In conclusion he agreed with Mr. Baker that many of the things which the author had said had been extremely unkind, and not at all in accordance with the facts.

Mr. de Segundo, in reply, said he really thought that Mr. Baker had misunderstood him, and he dared say that if they got together quietly they would find they were in more agreement than they thought they were. A certain wise man had said that nearly all the controversies in the world were verbal ones, and that if each man knew what the other meant it would probably be seen at once that controversy was either hopeless or unnecessary. It was quite possible for two people with the best possible intentions in the world to get at loggerheads. He had had no intention of saying anything that would wound the feelings of the representatives of the true Labour movement with which he had every sympathy. The main objectof his paper had been to direct attention to the fact that the mind of the country was being distracted by internal dissensions from the vitally important question of the loss of our foreign markets, and that unless our foreign trade was maintained it would soon become impossible for Great Britain to support its present population, with the inevitable consequence that we should cease to be a first-class Power.

On the motion of the Chairman, seconded by Mr. Baker, a hearty vote of thanks was accorded to the author for his paper.

STRAW BRAID INDUSTRY IN SHANTUNG.

Upon the opening of the port of Chefoo to foreign trade and residence in 1862, it was found that an important local industry existed in the plaiting of straw and the making of hats for the Chinese. Foreign exporters promptly saw the opportunities for trade with Europe in straw braid, and exports started from Chefoo, the braid going forward in sailing ships. At that time the local braids were known as Chefoo white, mottled, rustic and pearedge.

In the early days of exporting, braid was purchased by weight, the unit being the picul (133⅓ pounds). This method was later abandoned as the makers soon found that soaking the braid in water greatly added to its weight, although as a consequence, on the long journey to Europe the braid was ruined. Purchasing by the bale was then introduced, but no definite standard was established, the contents being noted by the number of pieces of special length. Later standard units were adopted and packages now consist of either 240 or 480 pieces of 30, 60 or 120 yards per piece. This standard has been definitely accepted by the Chinese.

Original patterns were all made of whole straw, but later, with the growth of the industry, Swiss and Italian fancy patterns were copied. With a view to plaiting lighter and more attractive braid the splitting of straw was started, and higher grade patterns are now plaited with split straw. As a substitute for Italian pedal, Laichow mottled braid was introduced and soon found a world-wide market.

The industry, under foreign impetus, has grown to such vast proportions that it is the main source of income for a considerable proportion of the population of north central Shantung Province. It has also extended to other Provinces, mainly Chili and Shansi. In fact, wherever wheat is grown straw braid is plaited.

Following the establishment of an important straw-braid market at Chefoo, exporters at Tientsin and Shanghai became interested, and later, after the building of Tsingtau, that city became an important market for braid. With the completion of the Shantung Railway and the more convenient transportation facilities offered, the trade was diverted from Chefoo to Tsingtau. Upon the outbreak of the European War Tsingtau was besieged and eventually captured by the Japanese, and of necessity the trade routes were altered again, bringing Chefoo forward as the straw-braid market. This, however, was only temporary, as Chefoo's handicap in not having rail communication with the interior makes it impossible to hold this trade. Should the Chefoo-Weihsien Railway be built there seems little doubt that Chefoo will be able to hold its own as an important straw-braid market, but it is doubtful if it will ever again become the premier market in China for this article.

From a report on the straw braid industry of Shantung by the U.S. Consul at Chefoo, it appears that the main producing centres of Shantung Province are in the Tsinanfu district and to the westward of the Chefoo district; and the most important centres of Northern Shantung are Shaho, Laichow, Pingtu, Changi, Showkwang and Yangsin, from which Chefoo draws its supplies. Of these centres only Laichow is in the Chefoo district. Braid from these districts is collected at Shaho, where it is re-assorted, packed, and transported to Weihsien on the Shantung Railway, to be marketed in Tsingtau and Tientsin, at present only relatively small quantities going to Chefoo. Sinchwang, Chaocheng and Kwangcheng are the producing centres of the western part of Shantung Province, with Nanlo, in Chili Province, and Tenghsien, Ningyang and Matow in the southern part of the Shantung Province.

The districts of northern Shantung produce the best grade and highest priced straw braid, and it is the better qualities and kinds of this braid which are marketed through Chefoo. Piping and split and all kinds of fancy-split patterns are made in this region. Laichow and Tientsin mottled, which are made in Sinchwang in western Shantung, no longer enter the Chefoo market, being conveyed by rail either to Tientsin or Tsingtau. Chaocheng and Kwangcheng mottled, also known as Laichow mottled, are the other principal braids of western Shantung. Prior to the building of the Shantung Railway these were all brought overland to Laichow and marketed in Chefoo.

The producing centres of south Shantung are of lesser importance, Tenghsien producing a small quantity of mottled braid and Ningyang plaiting two main qualities known as Ningyang white and Nangyang Tuscan. Matow formerly produced, in considerable quantities, a braid known as Matow Tuscan, which was marketed in Chefoo and also sent direct to Shanghai by junk, but at present this braid is not on the market, being out of fashion. Practically all the straw braid of Shantung Province is made of wheat straw, the only exception being a small amount of rustic braid made from barley straw.

During German occupation of the Kiaochow Peninsula serious efforts were made to introduce this industry into the neighbourhood of Tsingtau, but without success.

Foreign markets for straw braid are governed by changing fashions, and consequently great uncertainty prevails as to the probable future demand for any particular kind. Generally speaking, higher prices are paid in the American market than in London, and it usually follows that when the demand in America becomes slack the London market becomes active, and *vice versa*. Frequently American buyers cease direct importations from China and make

their purchases in the London market. France is a fairly heavy buyer, the trade for the entire country being centred in Paris. The smaller markets of the world are supplied by New York, London and Paris, and before the war Dresden, with China braids.

Straw used for making braid is sorted according to length and size, and the plaiting is done entirely by hand, the straw first being moistened in water to make it pliable. Comparatively small quantities of braid are made from whole straw. The straw is split by inserting a sharply pointed instrument with a varying number of cutting knives on the sides, the straw being split into pieces of equal width as desired. Fine straws are usually split into from three to five pieces and coarser straws up to seven pieces. The braid is then plaited according to the desired pattern of a uniform width throughout and the small projecting ends of straw are rubbed off. The finished braid is wound into bundles on specially built tables and over two wooden pegs, set so that their outside measurements will be exactly 16 inches apart. This not only ensures the bundles being uniform in size, but it also measures the braid.

The table on which the braid is wound is grooved crosswise in three places between the two pegs and twine is slipped along the grooves and under the bundle for convenient tying. The finished bundles are then placed in a box with wet sulphur in the bottom, and the fumes bleach the straw. In the trade this is not considered bleached braid, as it must undergo a proper bleaching process abroad before it can be used in the manufacture of hats and baskets. After this process the braid is delivered to the nearest collecting point, where it is assorted and packed and forwarded to the principal markets of the locality, such as Tientsin, Shanghai, Tsingtau or Chefoo. There it is unpacked, properly sorted, graded into qualities, and accurately measured, and all braids of the same quality, kind and exact size are finally packed for shipment abroad. Each bundle, which is known to the trade as a piece, is tied separately, and is either 30, 60 or 120 yards in length, and a package consists of either 240 or 480 pieces. High-grade straw braid made of split straw is packed in wooden cases for foreign shipment and plain braid, made of whole straw, is packed in bales.

Luton is the most important centre for the bleaching and dyeing of straw braid and the place where the art has reached its highest perfection. With altered trade conditions brought about during the war, and the fact that America is the greatest purchaser of straw braid and that American importers are steadily increasing their direct purchases from the country of supply, there is every reason to believe that in conjunction with the new dye industries in America the bleaching and dyeing of straw braid will become an important industry in the United States.

The exports of straw braid from Chefoo during 1918 increased about 20 per cent. over the 1917 shipments, but this may be considered as only a temporary gain due to existing local conditions, and upon the return of normal conditions in Tsingtau it is expected that the trade will return to that port unless Chefoo's interior transportation facilities are adequately improved. The total exports of straw braid from China are valued at approximately £600,000 per annum.

ESSENCE OF BERGAMOT INDUSTRY IN SICILY.

Among the minor items in the list of exports from Italy an important place may be assigned to essence of bergamot. According to a report by the U.S. Commercial Attaché at Rome, Italy's supply of essence of bergamot is derived from the island of Sicily. The plant belongs to the rue family, and the product of the distillation of the roots of this plant is known at essence of bergamot. The Italian Government has been at great pains to protect the industry by keeping this Sicilian product up to certain specified standards. The Sicilian peasant is at perfect liberty to distil bergamot root as he pleases, but the product may not be put upon the market until it has been brought to the Government laboratory at Messina and analysed and graded. It is then placed in copper receptacles and sealed by Government officials to prevent adulteration. While the stuff is not sold by the Government, it is sold under Government inspection. Essence of bergamot forms the base of many proprietary perfumes, and the demand for this Sicilian product is steadily increasing.

It is said that essence of bergamot in former times found its way to the American market through French and British intermediaries. That is no longer true. American agents are not only to be found in Sicily as purchasers of the distilled product after it has passed Government inspection, but they also go to the original peasant producer and buy options on the crops some months in advance of the period of actual distillation.

PRODUCTION OF TOBACCO IN JUGO-SLAVIA.

The most productive tobacco growing region in Jugo-Slavia is Serbia, which, within its frontiers of 1912, produced annually about 2,000,000 kilogs (4,409,000 lbs.), of which it consumed only 900,000 kilogs; the remainder being exported in leaf. The total production of Serbia and Macedonia, according to *Trgovinski Glasnik* (a trade journal) has increased to more than 4,000,000 kilos.

From a recent report by the U.S. Chargé d'Affaires at Belgrade, it appears that tobacco is extensively cultivated in the following regions:

In the Department of Skoplje, 500,000 kilos; in that of Bregalnitza (exclusive of the district of Strumitza), about 600,000 kilos; in the Department of Prilep, about 500,000 kilos; in Koumasovo, 600,000 kilos; in Vragais, 250,000 kilos; in Nish, 600,000 kilos; in Kruchevats, 300,000 kilos; and in Oujitse, 100,000 kilos.

Before the war, Herzegovina produced 3,500,000 kilos of tobacco, and there have been occasional harvests when the crop reached 4,600,000 kilos. The next crop, however, because of the post-war conditions, will not exceed 500,000 kilos. The most productive sections are in the south and east, the district of Mostar, Loubouchka, Stilats, Soubigne and Trebigne, as well as certain communes of the districts of Biletche and Kognits.

In Bosnia, the eastern sections are the most productive, especially the districts of Srbrnitsa, Vlasenitsa, and Svornik. In the north-east, the production is extensive in the districts of Belina, Brtchko, Gradatchatch, Bihatch and Sazin; in the south, in the districts of Prozor, Totcha and Tchainitche. Bosnia yields about 500,000 kilos of tobacco annually.

In Dalmatia the cultivation of tobacco has increased steadily since 1884; in 1913 it reached about 3,500,000 kilos, but since the war the production has decreased.

The exact amount of the crop in the Banat, the Batchka, the Baranya, and in Croatia and Slavonia is not known; but, according to Hungarian statistics, Hungary yielded 6,000,000 kilos, of which approximately 4,000,000 were produced in these Provinces. The most renowned tobacco sections of that portion of Hungary which have been awarded to Jugo-Slavia are: In the Banat, the districts of Vielki, Botchkorek, Jombal and Tchcka; in the Batchka, the central and northern districts in the Baranya, Boertch; in Croatia and Slavonia, Virovititsa Pogega, Pakrats, and Slatina.

The annual tobacco crop of Jugo-Slavia, therefore, approximates 15,000,000 kilos. Of this, some 6,000,000 kilos are required for domestic consumption, leaving 9,000,000 kilos for export, either in the leaf or prepared for immediate use.

GENERAL NOTE.

Chicle Gum in British Guiana.—Announcement has been made in a report submitted by the U.S. Consul at Georgetown, of the discovery of chicle-producing trees in British Guiana. Prospecting expeditions sent into the interior have returned to Georgetown with 600 pounds of chicle, and preparations have been made by the discoverer, who holds a concessionary right over 6,200 square miles of territory, to send out four prospecting parties in order to continue investigations and ascertain the productive capacity of the district. Territory thus far examined is reported to be capable of yielding 200,000 pounds of gum annually.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

March 16. — Charles Ainsworth Mitchell, M.A., F.I.C., "Science and the Investigation of Crime." The Right Hon. Lord Justice Atkin in the Chair.

April 6.—Professor Archibald Barr, D.Sc., LL.D., M.Inst.C.E., "The Optophone."

April 13.—Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Low Temperature Carbonisation and Smokeless Fuel."

Indian Section.

Fridays at 4.30 p.m.

April 22.—Lieut.-Colonel Sir Edward W. M. Grigg, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

May 27.—William Raitt, F.C S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

Indian and Colonial Sections.

(Joint Meeting.)

At 4.30 p.m.

Tuesday, May 3.—Sir Charles H. Bedford, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

Sir James P. Hinchliffe, "Research in the Wool Industry."

Sir Herbert Jackson, K.B.E., F.R.S., "Research in Scientific Instrument Making."

John Francis Crowley, D.Sc., B.A., M.I.E.E.

Dr. C. M. Wilson, "Industrial Medicine."

William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology,

"Brown Coals and Lignites: their Importance to the Empire."

Cantor Lectures.

Major G. W. C. Kaye, O.B.E., M.A., D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures.

Syllabus.

Lecture II.—March 14.—High Potential Generators—Open and Closed Coil Transformers—Influence Machines—Homogeneous X-rays—X-ray Measurements—Intensity and Wave-Length—Characteristic X-rays—X-ray Spectroscopy.

Lecture III.—March 21.—Applications of X-rays to Various Branches of Industry—X-rays in Medicine—Future Developments and Improvements.

Samuel Judd Lewis, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

MEETINGS FOR THE ENSUING WEEK.

Monday, March 14 .. Cold Storage and Ice Association at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m.

University of London, King's College, Strand, W.C., 5 p.m. Mr. W. G. Ridewood, "The Vertebræ of Elasmobranch Fishes."

Electrical Engineers, Institution of, at the Chartered Institute of Patent Agents, Staple Inn Buildings, Holborn, W.C., 7 p.m. Mr. R. L. Morrison, "Rectifiers."

Surveyors' Institution, 12, Great George Street, S.W., 7 p.m. (Junior meeting.) Mr. J. G. Elsworthy, "Conversion of Buildings to meet Modern Requirements."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. H. P. Adams, "Cottage Hospitals."

Transport, Institute of, at the Institution of Civil Engineers, Great George Street, S.W., 5.30 p.m. Major General Sir F. H. Sykes, "Civil Aviation."

Tuesday, March 15 .. Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Mr. J. Kewley, "The Crude Oils of Borneo."

Aeronautical Engineers, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 8.30 p.m. Dr. A. P. Thurston, "Points in the Design of Aircraft Structures."

Sociological Society, 65, Belgrave Road, S.W., 5.15 p.m. Mr. L. Simon, "The Hebrew University in Jerusalem."

Royal Institution, Albemarle Street, W., 3 p.m. Dr. A. Keith, "Darwin's Theory of Man's Origin in the light of Present Day Evidence." (Lecture IV.)

Electrical Engineers, Institution of (North-Eastern Centre), Armstrong College, Newcastle, 7.15 p.m.

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. The President, "Church Decoration in the Early and Middle Ages."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Mr. E. Torday, "Culture and Environment. Cultural Differences among the various branches of the Batetela."

African Society, Connaught Rooms, Great Queen Street, W.C., 8 p.m. Earl Buxton, "Presidential Address."

Statistical Society, at the Surveyors' Institution, 12, Great George Street, S.W., 5.15 p.m. Sir James Wilson, "The World's Wheat."

Wednesday, March 16 .. Imperial Arts League, at the Royal Society of Arts, John Street, Adelphi, W.C., 5 p.m. Annual General Meeting.

Meteorological Society, at the Royal Astronomical Society, Burlington House, Piccadilly, W. 1., 5 p.m. Dr. G. C. Simpson, "The South-West Monsoon."

Electrical Engineers, Institution of (Wireless Section), at the Institution of Mechanical Engineers, Storey's Gate, S.W., 6 p.m. 1. Mr. G. Stead, "The Effect of Electron Emission on the Temperature and Anode of a Thermionic Valve." 2. Miss W. A. Leyshon and Dr. W. H. Eccles, "Some Thermionic Tube Circuits for Relaying and Measuring."

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W., 11 a.m. 1. Address by the President (the Duke of Northumberland). 2. Sir Eustace D'Eyncourt, "Notes on Some Features of German Warship Construction." 3. Mr. S. V. Goodall, "Ex-German Battleship 'Baden.'" 4. Mr. W. R. G. Whiting, "The Strength of Submarine Vessels."

United Service Institution, Whitehall, S.W., 5.30 p.m. Captain A. Dewar, "The Necessity for the Compilation of a Naval Staff History."

Thursday, March 17 .. Aeronautical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Captain D. Nicolson, "Flying Boat Construction."

Illuminating Engineering Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 8 p.m. Major A. Garrard, "Motor Car Headlights: Ideal Requirement and Practical Solutions."

Royal Society, Burlington House, W., 4.30 p.m.

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W., 11 a.m. 1. Messrs. R. J. Walker, and S. S. Cook, "Mechanical Gears of Double Reduction for Merchant Ships." 2. Mr. E. W. Blocksidge, "Life-Saving Appliances on Cargo and Passenger Vessels." 3. Mr. M. E. Denny, "The Design of Balanced Rudders of the Spade Type." 3 p.m. Mr. H. B. Wyn Evans, "Standardization of Data for Airship Calculations." 8 p.m. Professor T. B. Abell, "A Study of the Framing of Ships."

Royal Institution, Albemarle Street, W., 3 p.m., Dr. G. C. Simpson, "The Meteorology of the Antarctic." (Lecture II.)

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Sir W. Noble, "The Long Distance Telephone System of the United Kingdom."

Numismatic Society, 22, Russell Square, W.C., 6 p.m.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m. Annual General Meeting.

Architects, Society of, 28, Bedford Square, W.C., 8 p.m. Mr. H. Bagenal, "Acoustics."

Friday, March 18 .. Technical Inspection Association, at the Royal Society of Arts, John Street, Adelphi, W.C., 7.30 p.m.

Royal Institution, Albemarle Street, W., 9 p.m. Sir Frederick Bridge, "Researches of a Musical Antiquarian."

Metals, Institute of, Mappin Hall, Sheffield, 7.30 p.m. Dr Rosenhain, "The Crystal Boundary."

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W. 11 a.m. 1. Mr. K. G. Finlay, "On the Spacing of Transverse Bulkheads." 2. Mr. A. M. Robb, "Deflections of Bulkheads and of Ships." 3. Mr. J. J. King-Salter, "Some Experiments on Tallows in their Use for the Launching of Ships."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m.

Saturday March 19 .. Royal Institution, Albemarle Street, W., 3 p.m. Sir Ernest Rutherford, "Electricity and Matter." (Lecture III.)

Journal of the Royal Society of Arts.

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FRIDAY, MARCH 18, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 21st, at 8 p.m. (Cantor Lecture.) MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." (Lecture III.)

CANTOR LECTURE.

On Monday evening, March 14th, MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc., delivered the second of his course of lectures on "X-Rays and their Industrial Applications."

The lectures will be published in the *Journal* during the summer recess.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 9th, 1921; VISCOUNTESS ASTOR, M.P., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Arnhold, Charles Herbert, London.
Bedford, James Edward, F.G.S., Headingley, Leeds.
Pearson, Colonel Henry Lawrence, D.S.O., Singapore.
Sen, Percy Arnold, Lucknow, India.
Stone, Lieut. Ellery Wheeler, U.S.N., R.F., San Francisco, California, U.S.A.

The following Candidates were balloted for and duly elected Fellows of the Society:—

Beardsell, Sir William A., Madras, India.
Bejal, Shiv Shankar, Morar, Central India.
Boyce, Eduljee M., B.A., Jhansi, United Provinces, India.
Bristow, Robert C., Cochin, S. India.
Chan Heang Thoy, J.P., Perak, Federated Malay States.
Hughes, William O., Bangor, N. Wales.
Kaul, Diwan Bahadur Sir Daya Kishan, K.B.E., C.I.E., Patiala, India.
Waring-Brown, Robert, A.M.I.A.E., Coventry.

A paper on "The Plumage Trade and the Destruction of Birds" was read by WILLOUGHBY DEWAR, Honorary Secretary of the Plumage Bill Group.

The paper and discussion will be published in a subsequent number of the *Journal*.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1921 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 26th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce," and has been awarded as follows in previous years:—

1864, Sir Rowland Hill, K.C.B., F.R.S.
1865, His Imperial Majesty, Napoleon III.
1866, Michael Faraday, D.C.L., F.R.S.
1867, Sir W. Fothergill Cooke and Sir Charles Wheatstone, F.R.S.
1868, Sir Joseph Whitworth, LL.D., F.R.S.
1869, Baron Justus von Liebig.
1870, Vicomte Ferdinand de Lesseps, Hon. G.C.S.I.
1871, Sir Henry Cole, K.C.B.
1872, Sir Henry Bessemer, F.R.S.
1873, Michel Eugène Chevreul.
1874, Sir C. W. Siemens, D.C.L., F.R.S.
1875, Michel Chevalier.
1876, Sir George B. Airy, K.C.B., F.R.S.
1877, Jean Baptiste Dumas.
1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S.
1879, Sir William Thomson (afterwards Lord Kelvin), O.M., LL.D., D.C.L., F.R.S.
1880, James Prescott Joule, LL.D., D.C.L., F.R.S.
1881, Professor August Wilhelm Hofmann, M.D., LL.D., F.R.S.
1882, Louis Pasteur.
1883, Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1884, Captain James Buchanan Eads.
1885, Sir Henry Doulton.

1886, Samuel Cunliffe Lister (afterwards Lord Masham).
1887, HER MAJESTY QUEEN VICTORIA.
1888, Professor Hermann Louis Helmholtz.
1889, John Percy, LL.D., F.R.S.
1890, Sir William Henry Perkin, F.R.S.
1891, Sir Frederick Abel, Bt., G.C.V.O., K.C.B., D.C.L., D.Sc., F.R.S.
1892, Thomas Alva Edison.
1893, Sir John Bennet Lawes, Bt., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.
1894, Sir Joseph (afterwards Lord) Lister, F.R.S.
1895, Sir Isaac Lowthian Bell, Bt., F.R.S.
1896, Professor David Edward Hughes, F.R.S.
1897, George James Symons, F.R.S.
1898, Professor Robert Wilhelm Bunsen, M.D.
1899, Sir William Crookes, O.M., F.R.S.
1900, Henry Wilde, F.R.S.
1901, HIS MAJESTY KING EDWARD VII.
1902, Professor Alexander Graham Bell.
1903, Sir Charles Augustus Hartley, K.C.M.G.
1904, Walter Crane.
1905, Lord Rayleigh, O.M., D.C.L., Sc.D., F.R.S.
1906, Sir Joseph Wilson Swan, M.A., D.Sc., F.R.S.
1907, The Earl of Cromer, O.M., G.C.B., G.C.M.G., K.C.S.I., C.I.E.
1908, Sir James Dewar, M.A., D.Sc., LL.D., F.R.S.
1909, Sir Andrew Noble, K.C.B., D.Sc., D.C.L., F.R.S.
1910, Madame Curie.
1911, The Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., F.R.S.
1912, The Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., G.C.V.O., LL.D., D.C.L., F.R.S.
1913, HIS MAJESTY KING GEORGE V.
1914, Chevalier Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.
1915, Sir Joseph John Thomson, O.M., D.Sc., LL.D., F.R.S.
1916, Professor Elias Metchnikoff.
1917, Orville Wright.
1918, Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S.
1919, Sir Oliver Joseph Lodge, D.Sc., LL.D., F.R.S.
1920, Professor Albert Abraham Michelson, For. Member, R.S.

PROCEEDINGS OF THE SOCIETY.

TENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 9TH, 1921.

SIR FRANK WARNER, K.B.E., Ex-President of the Textile Institute, in the Chair.

THE CHAIRMAN, in introducing the lecturer, Prof. Rothenstein, said that, having been engaged all his business life in the application of colour and design to textile fabrics, it gave him much pleasure to preside on the present occasion. But he had gone a little further than just minding his own business; he had studied the question of industrial art in a wider sense, and the more he studied it the more convinced he felt that it was a subject of great and increasing importance to the industrial welfare of the country. It should be remembered that this country had had remarkable periods of excellence in design. There were the glorious Mortlake tapestries, the beautiful Bow prints, the magnificent silk brocades and velvets of Spitalfields of the late seventeenth and early eighteenth centuries, the beautiful chintzes of the Georgian period, Chippendale furniture, Wedgwood pottery, and Adam architecture and decoration. Those were all things about which he could speak with pride, and there was no reason why we should decry the work that was being done to-day, for in many branches of industry some very beautiful products were being turned out. He was not satisfied, however—and he thought very few of those present that evening were satisfied—with what was being done to-day or with the way in which it was being done. There existed a lack of cohesion and a lack of pulling together between art and industry which was essential if a higher level was to be attained. Industry looked to art and said: "You are not giving of your best," and art replied in effect: "You do not give us sufficient encouragement." There was much to be said on both sides, and he would not deal with that aspect of the question any further at the moment; but, when those differences had been composed and sound principles had been laid down for the training and employment of designers and others who were engaged in producing beautiful things, he was confident that the improvement which was so much to be desired would come about. He hoped Professor Rothenstein's lecture and the discussion which followed it would be of assistance in that direction.

The lecture was:—

POSSIBILITIES FOR THE IMPROVEMENT OF INDUSTRIAL ART IN ENGLAND,

By Professor WILLIAM ROTHENSTEIN,
Principal, Royal College of Art.

Let me say at the outset that if Sir Frank Warner thinks that anything one individual can say or suggest at a moment like this can really be helpful, I am afraid he is doomed to disappointment. We all look forward to the ideal state of things which Sir Frank Warner has mentioned—not

only artists who have their own selfish creative lives to consider, but also artists of my age, who find it heart-breaking to see the talent there is throughout the country and, when appealed to for help towards the use of that talent, have constantly to say to young men of undoubted ability that we cannot give that help. This is so painful a situation that one cannot indulge in easy optimism.

The breach between creative people and the great manufacturers of the world is now a wide one, and I think nothing can be gained by denying it. So great is it that I think people are inclined to forget that the world was always a great manufacturing world, that such countries as India and China were great manufacturing countries. The quarrel that we artists and designers have with the great powers of the business world to-day is that, just as we honestly believe that we artists cannot be compared with the great men of the past, so we believe that our manufacturers to-day cannot be compared with the great manufacturers of the past. I take it that when we founded our museums and art schools, our belief and intention was that they should help to set an entirely new and exalted standard of taste. We do not require to be very learned to know that after the great Exhibition there were high hopes throughout the country that if we set up a great museum in London, and other museums, smaller, but no less important in their several ways, throughout the provinces, a great impetus would be given to artistic manufactures. Now, it is no use paying compliments to one another. We have really to deal with facts, and those of us who still keep the flame of the creative arts alive in this country or anywhere else in the world—humble as our efforts may be, must be and are—believe that it is only through the living creative spirit that that flame can still be kept burning.

We feel that the whole attitude of the museum has been becoming more and more of an acquisitive attitude and less and less of a creative attitude, and one of the ways in which I believe a beginning has got to be made some day, when we have thrashed the subject out, is a complete reconsideration of the place the museum has in the community. The museum of recent years has tended more and more in the direction of the wealthy collector. It has become a place whose directors try and acquire more objects than the museums of neighbouring countries possess; they feel that because a thing is very rare they must find a home in their own particular museum for that most expensive of all objects, and they require ever larger sums of money on acquiring rare objects, forgetting one of the principal reasons for the existence of museums in our midst, *i.e.*, to help creative people and the manufacturers throughout the country to solve their own difficult problems.

In a great metropolis like London, where scholars and students need museums for every kind of study, we naturally look for public collections which shall show every garment the human spirit has ever worn. But that is not the case in the provinces, where each of our big cities has got a museum, for the building and upkeep of which large sums of money have been spent. When we try to discover what particular purpose those museums really serve to-day, I think we shall find that my profession has got hold of them with a good deal of success, and that the limit of the ideals of most of our great municipal authorities is to provide heterogeneous collections of pictures which people may look at and discuss, and in which they may possibly find some pleasure. The main object of the museum, which is really to set the old with the new, to compare the possibilities of to-day with the possibilities of the past, and the powers of contemporary craftsmen with the powers of those of the past, has not been attained—that active side of the museum has scarcely yet come into being. I may mention that the other day I enquired how many of our great museums were energetically devoting themselves to the great crafts and manufactures of their districts, and I have in my pocket a list, compiled by an official from official sources, showing that nine museums in England have a direct bearing in their management and in their exhibitions on the great industries of this country. That is the first suggestion I would put before you, the serious consideration of how the past is going to help the present, because when you go to a museum you do not require a great deal of knowledge to see that the manufactures of the past—with the exception of machinery,— to-day, perhaps our noblest manufacture—such as the ordinary utensils of our households, our napery, silver, cutlery, furniture and hangings, everything which people used in

the ordinary business of life, were superior to those which we use to-day.

Now, the difficulty is this. Those of you who know something of the creative gifts of men and women to-day believe that with proper encouragement and a proper basis of society we can still produce things which will compare with those of the past. There are waves, we know—we have only got to look at any era of the past to see that a wave reaches its height and then begins to decline. But in the decline of a craft you can get another kind of exquisiteness and another kind of beauty, which may not be so noble, but which may, nevertheless, express a spirit of true culture and a fine appreciation of life. We all know that, from the point of view of pure æsthetics, the 18th century cannot compare with the 13th century, but the 18th century was distinguished by a delightful expression in every branch of the arts. Therefore, the problem that we artists and craftsmen have to deal with is this: Are we making full use of the human material of this country, and are our museums and universities and schools and art schools helping us to make use of it? To that question all those ranged on our side say: No. We actually know that a considerable number of men and women who desire to serve the community by their creative gifts are not given the chance of service which those who are called practical people are given. If a man intends to be an engineer, or a doctor, or a manufacturer or a lawyer, not only are greater chances given to him, but he is treated with infinitely greater social respect than people with creative gifts. Those of us who have the interests of the younger people at heart know that one of the great difficulties to-day arises from this fact, quite apart from any other; that the social position to-day of a young craftsman is not such as to gain him respect when he comes to obtain employment, a respect which creative gifts should entitle him to receive. Is it not the case that a designer in a great manufacturing firm sometimes receives a wage which would not be accepted by a village schoolmaster?

I am speaking of the general rule; there are, of course, exceptions; but the fact remains that the temptation for craftsmen to become teachers is becoming greater every day. Speaking of my personal experience, I may tell you that in the five or six months during which I have had the privilege of serving in a College of Art, I have had forty or fifty applications from every part of the country for teachers, and not one single application for a designer or craftsman. Now that seems to me to put the problem in a very simple form. Unless some greater incentive is offered to creative craftsmen we shall have more and more people teaching and fewer and fewer people doing, and what will happen? Whom are the teachers going to teach? In the end we shall have teachers teaching teachers, and a circle of teachers—for what end?

We are told that artists and craftsmen know very little of the practical conditions of commerce. We welcome all the help we can obtain from manufacturers or distributors. The difficulty from our point of view is that when we go to public banquets and to the opening of exhibitions we hear a great deal of noble lip homage paid to the arts and crafts, but when we really come to asking what the possibilities of service are for our craftsmen we meet, not with cynicism for a moment, but with the constantly reiterated statement that public taste is too bad to allow manufacturers to risk their capital and other people's capital on making good things. We on our side say that, however small our practical knowledge may be, the growth of curiosity shops throughout the country points to the fact that a very large number of people are not obtaining from the shops what their own tastes require, and that we are perhaps underrating the public taste in believing that they only ask for inferior things.

That is our great difficulty: we have not yet been able to make up our minds. We artists believe that public taste is better than most manufacturers and most distributors appear to believe, and I think that our first battle has to be fought upon that ground. We shall have to know very much more about public demands before we can be convinced that, if people were given, I do not say elaborately aesthetic objects of common use, but really sound and entertaining furniture, sound and entertaining things of every kind, enough people would not want good things to enable our manufacturers and distributors to provide them.

I feel that no vague idealism is going to help us, and those of us who have the interests of the younger people of England to-day to some extent under our care do

feel a very great responsibility in encouraging all these people to use their undoubted creative gifts until we have a greater power of giving them the certainty of being able to make use of what we do our best to teach them. I cannot imagine a more paradoxical or ironical situation than a country—or countries, because the same thing applies to all Europe—which has got art schools kept going by public funds everywhere, a country which spends large sums of money in giving students the best possible training, doing that, and then saying: "Now, we cannot promise that your gifts are going to be used." Can we really consider ourselves an advanced community, a civilised community, unless we know how to absorb the talents of our own people? It seems to me that a State is an ill-balanced State which cannot make use of the noblest output of its own citizens, and that is really the condition in which we are to-day, as far as the arts are concerned. Either we must frankly say that this is an age when we need engineers and not artists, or we must make use of the work of the artist. Mind you, I think you will find that artists will be among the first to pay homage to the magnificent work—not only the practical work, but the work of design, of compactness, of imagination, of extraordinary resource and initiative and energy—performed by the engineers of to-day. We are envious of them. We feel that engineers have these great qualities simply because they know instinctively that whatever in the way of initiative and resource they are ready to express somebody will be ready to understand and to receive.

I am not sure that, if we accept the situation, and frankly say that for a time we cannot afford to make fine manufactures, we shall not manage to look after our young people almost as well. The arts of painting, sculpture, architecture, and many of the crafts, have happily still an intelligent and a large public. But it is a heart-breaking situation that, unless a man has certain gifts—we will say the gifts of a portrait painter—we have to say to him: "We admit that your work is creditable, that people ought to make use of it, but the unhappy fact is, that there is small prospect of your gifts being acknowledged." That really is the situation to-day, and we want to appeal to business men and manufacturers to treat the subject most seriously.

If they do not consider their obligations to-day, I am not quite sure that there will not be some material price to pay in the future For while we have had in the past almost a monopoly of certain manufactures, other countries more and more desire to become self-sufficing, and a time may come when it will be less of an irony to suggest that we can do worse things than supply our own citizens with the things they need themselves for their own daily use, and we can do worse things than cease providing articles which people in other countries, in other civilisations, may possibly make better for themselves.

Anybody who has travelled in a country like India must know how painful it is to find a whole commercial civilisation entirely —I will not say destroyed, because the power of every country will re-assert itself in time—but dislocated through the imposition of goods made in a distant country to imitate their own. As I say, I think we could do worse than begin to think of what educated English people require in the way of the amenities of life, and when we think a little more of what we ourselves need, I believe we shall have made a very good beginning in making use of some of the craftsmen in our midst, because we cannot expect to obtain the very best work from our craftsmen unless we ask them to use for our own service certain gifts and certain aims which they share in common with us all. It seems to me fantastic that people in Italy, say, should have made their brocades, their furniture, their silver and gold work for another civilisation. The things we admire in the past were made for and used by the ordinary citizens of the time.

I can conceive a time coming when there will be a stronger public opinion on the matter, and when people will see that they obtain in the shops of their own cities the things which their education tells them they should not be without. Until our needs are treated with the respect due to a cultivated community, I do not think things will improve very much. But to gain this respect we must have knowledge, and the difficulty to-day is that, whereas practically every schoolboy knows all about aeroplanes, the most cultivated people in the country may not know the difference between a well-made table and a shoddy one. We are extraordinarily ill-informed on what constitutes a dignified household.

Whether we belong to what are called the working or wealthier class, we can scarcely lay claim to the name of a great nation if we are content to use shoddy things in our daily life instead of well-made things. It is bad political economy to expect people to make bad things quickly and cheaply when we ourselves, by asking for good things, ought to be employing the best hands and the best heads throughout the country upon intelligent and reasonable work.

I am sure Sir Frank Warner and everyone here who knows something about industrialism will agree with me that you cannot separate the moral question from the business question. You cannot go on for more than a certain time if commerce, which, after all, is the life of the nation, is based upon an altogether false ground. I do not see how we can approach this question without admitting definite moral responsibility, and one of our responsibilities should be to provide that the people who are specially adapted through their exceptional gifts to serve should be given a chance of service. If manufacturers say, as we have known them to do: "I agree with a good deal of what you say, but I took a designer from such and such a school and he was not any good," our answer is that so long have we ceased to make intelligent use of our best craftsmen that we do not quite know what to ask of them and they do not quite know how to respond. I think we have to appeal to people like Sir Frank Warner, who have these questions at heart, to be a little more patient with these craftsmen, as they are inclined to be with men who deal with scientific research. If we take a man and offer him a post as a scientific researcher we do not expect him to solve difficult problems immediately and begin to turn out inventions one after the other, but if one of our designers goes to a firm he is expected at once to do something which may seem to him for the moment to be undoing all he has learned, something which will be entirely new to him, and to do it with success. Now, I ventured to propose some time age at a committee meeting of members of the Federation of British Industries, that a certain number of research studentships might be offered to designers or craftsmen on much the same lines as those which are given to scientific men. At the present time—I do not think anything is gained by not speaking the truth in these matters—we send gifted designers from a provincial school, from the Royal College of Art or from one of the County Council Schools into an atmosphere where the position accorded them is not good enough to ensure the respect which their talents should win for them. Unless we can give those designers a position in which they are treated as extremely human beings, so that they slowly gain self-confidence in their strange surroundings, I do not think we shall get the best out of them. I should like to appeal to Sir Frank Warner and to anybody else in this room who is interested in the subject to consider that idea. I believe much good would be done if research studentships were offered to half-a-dozen craftsmen and designers, ensuring them a living for one or two years, allowing them to study, in addition to their knowledge of theoretical and practical design, the conditions demanded of designers and craftsmen to-day in the industrial world. They could then come back and report to the advisers, teachers and students at the art schools, suggesting where those schools might be wrong and where they felt industrial conditions to be unsuitable for certain people and suitable for others.

That is a small thing, but it would be a beginning, because, as Sir Frank Warner suggested, there is at the present time a divorce between what craftsmen are taught to do and want to do and what our manufacturers require them to do. I think, however, that we must be absolutely adamant on this point; there must be no question of turning our art schools into merely higher technical schools. Our business is to give young craftsmen the same kind of education through the arts that other students obtain at the universities, and, although we desire in every way possible to consider the manufacturers' needs, we must be allowed to give to our young students, through the practice and study of the arts, that education which we feel is their due. Perhaps there is a tendency to-day to look upon the provincial art school as useless because it does not turn out men ready to go at once into the local industry as designers or craftsmen.

I think manufacturers must realise that a craftsman has a right to all the education we can give him. If we send our sons to Oxford and Cambridge we give them what we believe to be education; we do not

educate them for a particular vocation. And, though we desire by every means in our power to fit our craftsmen and designers to be most useful members of the community, we cannot teach them what we consider to be sound methods and then encourage them to discard these for less worthy and sincere means. That, I think, is the second point that we have to settle among ourselves; otherwise we must have complete divorce between art and industry. I believe those of us who care for the dignity and beauty of life expressed through the arts would rather young people were trained for other careers than encouraged to prostitute creative gifts.

We must try and find a basis to work upon, on the understanding that our manufactures should not be ugly things, but fine and honest things, and we believe that we can help to make them so. We do not seem quite to have made up our minds on that point. If the idea prevails that there is something a little ignoble about manufactures and something distinguished about art, I venture to say there must be something amiss in our commerce. For both manufacture and art are perfectly normal activities, and if we cannot find some way of uniting them it is difficult to see how this country can keep the place it has occupied in the past. The marriage must be a good marriage; each must behave well to the other; there must be no bullying on the part of the stronger partner. So long as craftsmen feel that the material power of the people who employ them is so great that they cannot quite stand up as their equals in ability and usefulness, we shall find a sense of discomfort existing between art and industry.

I have only touched upon two points, because I do not think it is worth while confusing the issue, and I am sure that people in this audience with infinitely more experience than I have will be able to carry on the discussion in a more fruitful way than that in which I have been able to begin it.

[The above address was given extemporaneously and is published as taken down by the shorthand-writer.]

DISCUSSION.

MR. A. F. KENDRICK (Department of Textiles, Victoria and Albert Museum), said he agreed with the Chairman and the lecturer in not being satisfied with the present relation between designers or craftsmen and manufacturers in in this country, and he thought everyone else in the room would agree on that point. That seemed to him to be a healthy sympton. When people were satisfied they never made any progress: it was when they were not satisfied that improvements were made. With regard to the author's remarks about museums, he agreed that museums were not by any means perfect, and he would be glad if the lecturer would say what should be done to improve museums. He did not agree that museums were spending more and more money; one of the troubles now was that they were spending less and less. The lecturer also said that museums were acquisitive. With regard to that point, a short time ago he was showing a visitor to the Victoria and Albert Museum half of a very fine work of art and mentioned that he happened to know where the other half was and had done his best to secure it, so that the two halves could be put together. The visitor accused him of being greedy, but he replied that he was not greedy; he anticipated a public greed and he wanted to meet it. It was very desirable to get the public into the museums. The manufacturer said: "A designer comes to me with a design and I ask him what it is for, whether it is for a wall-paper or a piece of china, and he says I can use it for what I like." There was something wrong with that state of affairs. The designer took up the tale and said: "The manufacturer will not give me my price and he is not prepared to consider my designs." Some years ago, about the time of the outbreak of the war, he asked at one of the large shops in London whether they had many English designs reproduced. The man whose duty it was to select designs replied that they did, and on being asked whether he preferred them to foreign designs, said that the English designers were clever enough but he had to keep a design school on his premises in order to turn the English designs into something practical; whereas the designs sent from Germany and other places before the war, did not require any alteration before being reproduced. The designer and the manufacturer were very much like other people, like the general public, and what it was necessary to do was to get at the public. That was the purpose museums were meant to fulfil. At present at any rate, they were not teaching institutions; they were institutions where objects that were supposed to be useful to students were collected together and facilities were given to students to make such use of those collections as they thought best, and those were the lines on which museums should be developed. Certain London museums now had an average of 3,000 visitors a day, and assuming one-tenth of those came with the intention of learning something, and not merely as idlers, that gave 300. Supposing

the 3,000 could be raised to 10,000, he thought the one-tenth would still stand, and there would then be 1,000 people a day visiting the museum for a serious purpose. The public must be induced to come into the museum. That would raise their standard of taste, and when the public wanted good things they could get them. If the public taste could be improved many of the troubles of designers would be over, and the manufacturers would fall into line. Whatever might be the faults of museums and such institutions, the London ones at any rate were free; they were fairly well warmed and lit and some effort was made to show the things worth seeing, and the members of the public had only to go there and make use of what was their own.

Major A. A. Longden, D.S.O. (Director, British Institute of Industrial Art) said he entirely agreed with the point of view of Prof. Rothenstein. He thought there was too little understanding between the various art schools, which, in his opinion, ought to co-operate. The general feeling in the past about the Royal College of Art was that it was a training centre for teachers. Prof. Rothenstein mentioned that numerous applications were made to him for teachers, but none for designers. On the other hand, if enquiries were made it would probably be found that such schools as the L.C.C. Central one had no applications for teachers, but a great many for designers. Doubtless, under Prof. Rothenstein's able guidance, the state of things would rapidly improve in the College. With regard to museums, they were, as a rule, dull places, and he did not think the general public could be induced to go to them unless a big propaganda and advertising campaign was undertaken to tempt them thither. They would return again if they once went there, but there was no outward inducement to them to go. A campaign should also be begun with a view to persuading the manufacturers to take more risk, and instead of supplying the public with almost similar goods year by year gradually treat them to work slightly better and more modern in design. Another group of people that should be tackled were the big buyers, who dictated their terms to both sides; they told the manufacturer that if he could not make a certain article they could get it made next door, and they told the salesman that if he could not sell an article he would lose his employment: thus the latter was compelled to sell what the public did not want. There must be some form of unity; each side must give way a little. Exhibitions of Crafts and Artistic Manufacturers could also do much for the people, but it should be realised that it was impossible for any one committee to select work for the whole community. All points of view must be taken into consideration. There were, for example, accepted standards of taste in the Fine Arts entirely different in outlook, *i.e.*, the Royal Academy, the New English Art Club and other societies, all varying in point of view and yet accepted by the various groups of the public as representative of the Fine Art of the moment, similarly no one group of judges in the crafts could decide what was right for all. If the different societies who were interested in the unity of art and industry consulted one another they could, he felt sure, tackle these problems adequately.

Mr. Arthur Wilcock said he had listened to the paper with very great pleasure. He would like to ask the lecturer whether the young people referred to in the paper could be trained for shops and warehouses, because that was where they were wanted. When people asked him why good designs were not being bought, he replied that it was for the simple reason that there was no one to sell them. Just as good men were required at the selling end as at the designing end, the schools seemed to have wrongly concentrated their attention on creating and encouraging designers and to have given no attention, or very little, to the selling end. He had recently been inspecting some of the schools in the north, and he was very pleased to see that so few designers were being trained there. The students were all good craftsmen, and it seemed to him a very healthy sign that they were good craftsmen who were anxious to know a little about design, although most of them were engaged in weaving plain goods. Their exercises in design were very simple and good and praiseworthy. In the classes of embroiderers and decorators, it was very encouraging to see young craftsmen trying to make themselves artists rather than artists trying to impress themselves upon a craft. If only the schools of art could be turned for a time into academies of taste to teach the students what was really beautiful, and to contrast the beautiful with the ugly, he thought those schools would be fulfilling their true function. It was very laudable that the teaching of design in our schools of art should be the highest possible, but would it not be wise to try and discover first if such excellence could be absorbed into the industrial body which was, at present, badly functioned to assimilate better design. Was Prof. Rothenstein aware also of the fact that it required only one really clever designer to keep going three or more large mills employing some hundreds of workers?

Mr. H. P. Shapland, A.R.I.B.A., said the question was how to bridge the gulf between the art student, who was full of energy and ideals, and the manufacturer, who was very busy and had little time to listen to the student. Many years ago, when he was engaged in manufacture,

he was visited by a man who said he had been trained at South Kensington as a furniture designer, and now wished to come into the factory to learn how furniture was made. Within the past twelve months, a friend of his, an artist, put him in touch with a young student from the Royal College of Art, who designed for him a very good poster, but she knew nothing about the cost of production and the number of colours that went to make the poster. She was able to produce a very good design, but the question of producing it in a practical way had never entered her head at all, or the minds of those who had taught her. That seemed to him to be a very great difficulty. The lecturer had appealed for understanding between manufacturers and artists, and it was true that both sides needed it. When a busy manufacturer obtained a designer from the Royal College of Art, a man who could perhaps draw very beautiful posters or design very beautiful furniture, and found that that man did not know how those things were produced practically, he came to the conclusion that artists were a lot of "high-browed" people who really were not efficient and did not know their work. The artist, on the other hand, might be a man of splendid principles and full of clever ideas, but he was utterly bewildered by not knowing what the manufacturer required, and by his lack of workshop training. He thoroughly endorsed Mr. Kendrick's remarks about manufacturers who kept craftsmen and designers to put into shape and make practicable for machinery the designs which young designers produced.

Mr. Hamilton T. Smith (Vice-Chairman, Design and Industries Association), said he agreed with Mr. Wilcock as to the importance of the selling side of manufacture. It was impossible to overrate the influence for good or evil of the distributor—he thought in general it must be said that at present it was for evil. The manufacturer was often quite honestly desirous of making good things, and he was in the advantageous position that, if he was an honest and able man, he knew something about what he was making and was anxious for his own sake—as every man who made things was anxious—to make his productions as well as he could. The subject under discussion was not pictures or statues, but things that were in common use every day, and the important point about them was that they should first of all be fit for their purpose. The manufacturer was anxious in many cases to make things fit for their purpose, and the experience of the past, from pre-historic times down to at any rate the time of Sheraton, showed that, if things were made with singleness of mind to be fit for the uses to which they were going to be put, it was extremely difficult for a man to make them either ugly or unpleasant. It was only in the nineteenth and twentieth centuries that people had solved the mystery of making things ugly, but he thought we should gradually return to the state when people made things beautiful because it was much more easy and pleasant to make them beautiful than ugly. The manufacturer, however, was hampered at every stage by the bugbear of public taste to which reference had been made in the lecture. The lecturer said that public taste was a great deal better than it was made out to be, which seemed to show that he was in danger of believing in the reality of that bugbear. He did not believe there was such a thing; no particular phenomenon could be separated from others and called the public taste. The public was an entirely amorphous and inarticulate body; nobody had ever yet discovered what it wanted and it did not know itself. The public wanted what the skilful salesmen offered it. Manufacturers were often told by the retailers that certain articles were very nice but the public did not want them. He had known more than one instance of that kind of thing. A manufacturer in Sheffield made some very beautiful rustless table knives, not of the ordinary parallel-bladed round-ended type, but more after the old model which had a somewhat scimitar-shaped blade, thoroughly efficient as a cutting tool and easy to look after, as it had not got the projecting flanges which were difficult to keep clean. The manufacturer tried to get those knives sold by distributors, who all said that they were not the kind of things the public wanted, that their shape was funny, and so forth. The result was that the manufacturer had to take the knives off the market. Personally he had managed to procure the last set of those knives, and everybody who saw them remarked on their beauty. That incident seemed to him to be the whole problem in a nutshell. The manufacturer wanted to make those knives, and whenever an individual member of the public had a chance of expressing an opinion he said he wanted to buy them and asked where he could do so. The shopkeeper stood between those two people like a solid stone wall and prevented them seeing one another, telling one side that the knives were not to be had and the other side that they were not wanted. Personally he did not think it was much use tackling the salesmen or the buyers. If a distributor had a sense of the merchandise that he sold, if he felt he was something more than a man taking in goods at the back door and putting them out at the front, and making so much per cent. on them, then that distributor would sell the kind of things those present that evening wanted him to sell. The man at the head of a distributing business must have judgment, some technical knowledge of the things he sold and some sense of what constituted a beautiful as against an ugly thing, and then his buyers and salesmen would sooner or later come into line. When that desirable state of affairs was attained he thought the

manufacturers and the public could be allowed to look after themselves.

PROF. PERCY E. NEWBERRY said he came to the meeting to learn and he had learned a very great deal from what the author had said. He thought salesmen had a great deal to do with improving the public taste. In going through antiquity shops, as he had for the last thirty years, in Cairo, Constantinople, Paris and so on, he had learned to discriminate mainly from the salesmen in those shops. They were nearly always cultivated men who knew exactly what they were selling, and he felt that his own taste had been cultivated in a very great measure by the salesmen of those shops of the Orient and of the Nearer East.

MR. CATTERSON SMITH said that with regard to museums, he felt the great mass of objects in them were made by methods very different to those at present employed in manufactories. A student visiting one, and looking at the work there, obtained very little aid with regard to modern requirements. For a very long time he had felt that the educational value of museums would be greatly enhanced if a number of properly qualified lecturers were in them to explain to the public the methods of manufacture, their history and the art qualities of the work. Often, when he had been in a museum, and had begun to explain something to someone near him he soon found a group of people round him, and that he had become involved in giving a little lecture; the little group always seemed grateful and interested, and they probably learned very much more in that way than they would if left to themselves. When coming into contact with manufacturers he had found some who undoubtedly had high ideals in regard to craftsmanship, but they confessed that it would be extremely difficult for them to make any change in their methods of manufacture. Some honestly said they were out to make money. He had been at the head of a school of art for a good many years, and was satisfied that there was any amount of talent in the country, but there was really little or no demand for the best quality of talent. The man who was wanted was one quick at picking up ideas and designing the kind of thing likely to sell. That type of person was not an artist or likely to do credit to himself or to the nation, and it was desirable to supplant him in some way or other. He agreed with the lecturer that it was not possible to make a complete change for the better suddenly. A manufacturer once asked him for a very simple and refined design for a finger plate, and his reply had been that that was a most difficult thing to supply, for the standard of taste in the trade had been low for so long that it had made it impossible to produce a good design on demand. The student was not tempted to aim at such work; he was tempted in showy directions, and to obtain a design for a finger plate that was really good, and not over ornamental, was extremely difficult. Much was said about good structure and the consideration of utility, and he quite understood all that, and believed in it, but, at the same time, it must be remembered that there was a strong love in mankind for ornament. Taking young students, say, boys and girls of fourteen years of age, it would be found that they were not keen about questions of structure and utility, but were keen about ornament. The idea that a thing was certain to be beautiful because it was well constructed was not the whole truth by any means. A number of people preached that doctrine but he was quite sure they would have great difficulty in persuading young students to accept it, and he thought young people should have an opportunity of expressing their instinct for ornament.

THE CHAIRMAN (Sir Frank Warner, K.B.E.), in proposing a vote of thanks to the lecturer for his interesting address, said that, although Professor Rothenstein had said the industries were not accustomed to go to the Royal College of Art for their designers, certain branches of the textile industry, at any rate, largely employed designers who had received their training in the art schools throughout the country. All his own designers had been trained at a provincial school of art, and, unless he happened to come across some genuis such as he had never yet discovered, he would not think of going anywhere else but to a school of art for a designer. It was, perhaps, an unfortunate fact that the Royal College of Art had not succeeded in obtaining the confidence of manufacturers, but he was hoping that under the new régime that confidence would be established. Speaking as a manufacturer, he would be only too glad to go to the Royal College of Art and see if he could obtain a super-designer who could come and help him in his business. One point on the other side that ought to be considered was that in the past, so far as he knew, the remuneration of trade designers had not been what it ought to have been. He was afraid that very often designers — whether they came from a school of art or not—working in the design atelier of a manufacturing firm were not paid that rate of salary which they deserved. That department had always been looked upon as a poorly paid one. He believed that one of the solutions of the problem under discussion would be for industry to recognise that the design department was one of the most important in a firm, and to offer such salaries as would attract talent. Money had a wonderful power. It could not do everything, but one could not expect young men to go to the Royal College

of Art and devote their time and energies to qualifying for a manufacturing business at a paltry salary when they could go into some other profession and obtain a much better salary. He had been giving the question of industrial design close consideration for a good many years, and he found that the attitude of the art schools towards industry was very different at the present time to what it was when he first took up the subject. To-day there was a desire on the part of the art schools to help the manufacturers, and, on the other hand, the manufacturers were waking up to the importance of industrial design and of obtaining the best, regardless of the cost. Before the war, it was customary for Continental designers to send their representatives to manufacturers in this country with enormous quantities of designs for every kind of manufacture, and that state of things was gradually returning. Personally, he wanted to see British goods with British designs on them drawn by British designers, and he wanted people to set to work to bring that about. He thought that was one of the objects of the present meeting, and he hoped that what had been said by the lecturer and by the speakers in the discussion would help towards that position. Industry as a whole had an insatiable appetite for design. The consumption of designs, especially for seasonal trade, was enormous. It might seem rather a depressing thing to say, but the better the designs the fewer would be required, because good designs would last for years, whereas poor designs were cast aside after a few weeks. Apart from that, however, the reason why new designs were required—and by "design" he meant not only outline but material, colour, shape and ornamentation and everything included in design—was that the design of yesterday was not the design of to-day, and the design of to-day would not be the design of to-morrow. Therefore, those interested in the subject must be continually going on, and they ought to try to get on to a higher plane and climb upwards, higher and higher, until they reached a better state of things than they had ever known before.

The vote of thanks having been seconded and carried unanimously,

PROFESSOR W. ROTHENSTEIN, in reply, said that, as a practical beginning, he would like to propose that half a dozen research studentships for designers should be established, so that the difficulty mentioned by Mr. Shapland, of designers not knowing what they were expected to make would be overcome. Was it too much to hope that, just as Chairs at Universities were founded by the generosity of private patrons, so one or two special workshops, and one or two special lectureships might also be founded in the art schools of the country, thus putting those schools on the same level as the Universities? Artists felt their ineffectiveness as opposed to the enormous effectiveness of business men, who always managed to secure a thing if they wanted it. Artists believed absolutely that the creative faculty was the noblest faculty of mankind, and were distressed at young students always being fobbed off with hopes and kept waiting and waiting. He would like to be instrumental in making one great merchant prince say "Yes, I believe in what you have said." That was really why a few artists, who were busy men, and did not think they could influence anybody very much, still did what they could to influence manufacturers and others with the faint hope that this country would help its creative people as it helped its scientific men and engineers. Something might be done in that direction if one or two of those who cared about the matter would make a beginning in the way he had suggested, and see if something could not be done to put young craftsmen into touch with industry in a more practical way.

The meeting then terminated.

OBITUARY.

LORD MOULTON, P.C., G.B.E., K.C.B., K.C., F.R.S., LL.D.—By the sudden death of Lord Moulton, on the 9th inst., at his house in Onslow Square, the Society loses an old and valued member. He was elected in 1881. He served on the Council from 1890 to 1893, and again from 1914 to 1918. He always took a keen interest in the Society's work, presiding at several meetings and speaking occasionally in the discussions. As a member of the Royal Commission for the Chicago Exhibition of 1893, he contributed his share to the organisation, and went to Chicago as a representative of the Society. He was to have presided at one of the meetings next month.

Born in 1844, the son of a Wesleyan clergyman, the Rev. James Egan Moulton, he went from the Wesleyan New Kingswood school to St. John's College, Cambridge, in 1864. In 1868 he completed a distinguished University career by becoming Senior Wrangler and First Smith's Prizeman. Immediately after taking his degree, he was elected a Fellow of Christ's, of which College he was for a short time a Lecturer. In 1873 he resigned the Fellowship and in 1874 he was called to the Bar at the Middle Temple. He soon specialised in Patent Law, for which his wide scientific knowledge specially qualified him, enabling him to act, not only as an advocate in patent cases, but as a scientific expert and consultant in all

matters connected with Letters Patent for Invention. In this branch of his profession he rapidly developed a large and lucrative practice, so that in a very few years he was recognised as being quite the head of it. It may be admitted that this position was due to his great scientific knowledge and capacity, for, as an advocate in Patent cases, he was by competent judges less highly esteemed than his earnest and laborious rival Richard Webster (afterwards the Lord Chief Justice, Lord Alverstone). Had Lord Moulton devoted himself to a purely scientific career, he would probably have attained even a greater and more permanent reputation, but as it was, his subtle intellect and his wide acquirements brought him an enormous practice, and probably greater pecuniary results than pure science could ever have afforded him.

He sat in the House of Commons as a Liberal from 1885 to 1906, representing Clapham, South Hackney and Launceston. In 1906 he became a Judge of the Court of Appeal, and in 1912 a Lord of Appeal.

On the outbreak of the War, he practically threw up his legal work, and patriotically devoted himself to the supply of munitions, in the capacity of Director-General of Explosive Supplies. Here he found congenial work, and work the value of which it would be difficult to overrate. The country was fortunate in finding a man with knowledge to see what was required, capacity to devise improvements himself, and to appreciate the suggestions of others, and energy to enforce and compel the adoption of the improvements that were needed. His ardent devotion to his duties may have shortened his life, and cost him a few years of old age, but his work was completed before the end came, and the last few years of a long and laborious life added a special lustre to Lord Moulton's distinguished legal career.

PIG BREEDING IN SCOTLAND.

One of the most interesting developments in Scottish agriculture has been in progress for some years in connection with the breeding of pedigree pigs. The white breeds of pigs have many admirers in Scotland, but export in these to warm countries is limited in consequence of their liability to sun-blistering. The black breeds are preferred for tropical and sub-tropical countries, and notably the Large Black breed, which has come into such prominence for other purposes in recent years. A few years ago it would have been hard to find any number of Large Blacks in Scotland, as there existed an unreasoning prejudice against the breed, it being generally understood amongst farmers that the breed would not thrive under the rigorous climatic conditions in Scotland.

These prejudices, like many of their kind, have passed away, and, as a consequence, there are now over fifty herds of Large Blacks north of the Tweed. Perhaps the high prices realised at all the sales of Large Blacks for the last two years has had something to do with the change.

The Large Black Breed Society has done much to foster the development of the breed in Scotland, and managed to get the Highland and Agricultural Society to institute a class for these pigs at the Highland Show at Aberdeen last summer. The class as exhibited, was not very satisfactory, and this was doubtless due to the fact of the exhibitors being somewhat new to the breed and also to the classification, which did not commend itself to many. Next year there will be, it is hoped, a more extended class at the Highland Show, as one or more cups and prizes will be offered by the Large Black Breed Society.

The breeding of Large Blacks in Scotland, to any great extent, was instituted by Mr. Loudon MacQueen Douglas, of Edinburgh, some years ago, and the Douglas Herd may be said to have been the pioneer of the others which have followed. The pigs from the Douglas Herd are known in many parts of Scotland, but more especially in overseas countries, where the owner has travelled, and thus become familiar with the conditions governing pig breeding there. It is, for example, noticeable in a country like South Africa that different races of pigs are very susceptible to atavism or harking back to the original type. In some cases this harking back would be really amusing if it did not mean such a loss to the pig breeders. Curiously enough, the Large Black is not so susceptible to climatic conditions, and has withstood the test now for many years. It is nearly ten years ago since Mr. MacQueen Douglas first sent out Large Blacks to South Africa, and the descendants of those sent out thus, and others which have followed, now amount to many thousands: in fact, the South African Herd Book now includes about 100 pages of entries of Large Blacks alone—a fact which speaks for itself. For bacon purposes it has been found that a cross between the Berkshire (using a Berkshire sire) with the Large Blacks, is most effective.

Quite recently the Douglas Herd was called upon to supply typical specimens of the breed in Portugal, and with the result that, in addition to supplying the requirements of South Portugal breeders, it has been decided to establish a herd in North Portugal, which will be kept at the Quinta da Piedade, Povoa de Santa Iria, which is a beautiful estate owned by Mr. John L. Wilson, near Lisbon. The Portuguese herd will be developed as the Douglas-Wilson Portuguese herd of Large Black pedigree pigs, and will, no doubt, supply many animals for breeding purposes in Portugal and the Portuguese Colonies overseas.

WOOD PULP MANUFACTURE IN ARGENTINA.

The utilisation of the forestal riches of the Misiones Territory of Argentina for the manufacture of paper pulp is a suggestion which has met with favour amongst those interested in developing this industry in that country. One of the special advantages possessed by the Misiones Territory for the wood pulp industry, writes the U.S. Trade Commissioner in Argentina, is that adequate means of transportation by water are available.

This Territory, containing about 11,700 square miles, is in the extreme north-west of Argentina, lying between the Rivers Parana and Uruguay, which, in that region, average about 50 miles apart. Since the Parana is navigable for large steamers, water communication can be maintained with Buenos Aires, Montevideo, and other ports. Misiones is tropical and heavily wooded, more than 700 varieties of trees having been counted; among these is an abundant tree, called caragnatazol, said to be very well suited for paper pulp.

Almost all of Argentina's supply of paper is received from other countries, and in proportion to the population there is a considerable consumption of paper and paper products. At the same time, there are several local paper mills which import pulp and waste products to a certain extent.

Although the Territory of Misiones is sparsely settled, it is one of the sections to which immigrants are now turning. A holding, containing 416.800 acres, covered with heavy forests with an abundance of Araucanian pines 65 feet high, was recently offered for sale at about two dollars per acre.

NOTES ON BOOKS.

THE BRITISH JOURNAL PHOTOGRAPHIC ALMANAC, 1921. Edited by George E. Brown. London: Greenwood & Co.

This is the sixtieth issue of the well-known photographic annual, which was first published in 1860, in the form of a wall calendar, as a supplement to the British Journal of Photography, and in 1861 as a separate volume, issued gratuitously to subscribers to the Journal. The present form was adopted in 1866, and this was the first to be sold exclusively as a separate publication.

The Editor apologises in his preface for not celebrating the occasion by some special feature, but his statement that the present costs of publication render any fresh expenditure quite impossible, may well be accepted as sufficient excuse, if any excuse were necessary, as it is not. The volume, indeed, has diminished in size. In pre-war times it had reached an average of some 1,500 pages, whereas the current issue contains only 840, and if the diminution in size is compensated by an increase of price from 1*s.* to 1*s.* 6*d.*, it may safely be assumed that now, as in previous years, it is really issued to the public at a price somewhat below the actual cost of production. That the Almanac is as popular as ever, is shown by the statement that the edition has been raised from 25,000 to 30,000, while even this large number is said to be insufficient to meet all demands.

In 1866, Photography was still in the early stage of development. The only industry connected with it was that of portrait-making, which was dependent on a single process, that of wet collodion, and its practical applications either technical or scientific, were very few and unimportant. There were a good many amateur photographers—the Amateur Photographic Field Club, still flourishing, was founded in 1865, and the value of photographic records was beginning to be appreciated. Now the manufacture of photographic materials is a very large and important industry, the applications of photography in science, art and industry are innumerable, and everybody, at home and abroad, seems to carry a Kodak about with him. Through all the long period of change and development, the Almanac has faithfully recorded progress, and year by year its successive volumes have provided a compendious account of gradual and continuous growth.

The present issue is as complete as any of its predecessors, and indeed its decrease in bulk is rather an advantage than a drawback, since it has tended to condensation, and to the omission of a good deal of what was really superfluous.

The annual summary of photographic progress, Mr. Brown this year devotes entirely to the ubiquitous modern photographer, who contents himself with snapshots which he gets developed by a professional, and is practically quite ignorant of the technical details of the process he employs. If those, who devote themselves to the practice of this sort of photography would read this article, they would certainly improve their results, and would add a great deal to the interest of their pursuit. The bulk of the book, however, appeals more directly to the scientific student of the subject, and he will find it as useful and as valuable as usual.

Those who are interested in the history of photography may be grateful if their attention is drawn to a History of Photography near the end of the volume, which gives a compendious record in chronological order of all the chief discoveries, inventions, and events connected with photography, from Wedgwood's attempts in the early years of the nineteenth century to print outlines of objects on paper sensitised by nitrate of silver, down to the latest inventions of the present date. To say the list is complete would not be possible without careful and minute examination, but it may certainly be stated that a cursory study of the earlier history has not suggested any addition of importance, except perhaps, a reference to Robert Hunt's "Researches in Light," 1844.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

APRIL 6.—ARCHIBALD BARR, LL.D., D.Sc., Emeritus Professor of Engineering, University of Glasgow, "The Optophone—an Instrument for Enabling the Blind to read Ordinary Print." (A Demonstration of the Instrument will be given.)

APRIL 13.—PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Low Temperature Carbonisation and Smokeless Fuel."

INDIAN SECTION.

At 4.30 p.m.

FRIDAY, APRIL 22.—LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

TUESDAY, MAY 3.—WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

JUNE 10.—SIR GEORGE SEYMOUR CURTIS, K.C.S.I., "The Development of Bombay."

INDIAN AND COLONIAL SECTIONS. (Joint Meeting.)

At 4.30 p.m.

FRIDAY, MAY 27.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

DR. C. M. WILSON, "Industrial Medicine."

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

CANTOR LECTURES.

MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc. (National Physical Laboratory), "X-Rays and their Industrial Applications." Three Lectures.

Syllabus.

LECTURE III.—MARCH 21.—Applications of X-rays to Various Branches of Industry—X-rays in Medicine—Future Developments and Improvements.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures. April 11, 18 and 25.

*MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 21..Automobile Engineers, Institute of, Royal Technical College, Glasgow. 7.30 p.m. Dr. W. H. Hatfield, "Automobile Steels."

Brewing, Institute of (London Section), at the Institute of Chemistry, 30, Russell Square, W.C., 8 p.m. Mr. F. A. Mason, "Pests and Diseases of Barley and Malt. Part I.—Injurious Insects."

Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. J. M. Wordie, "Present Day Conditions in Spitsbergen."

Architectural Association, 34, Bedford Square, W.C., 8 p.m. Messrs. M. Sparks and A. Hull, "The Rise of the Guild of Builders."

East India Association, 3, Victoria Street, Westminster, S.W., 3.30 p.m. Mr. B. C. Vaidya. "A Historical View of the Political Unity of India."

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C., 5 p.m. Mr. G. S. W. Epps, "Superannuation Funds. Notes on some Post-War Problems, together with an account of a Pensioners' Mortality Experience (Civil Service Pensioners, 1904-1914)."

TUESDAY, MARCH 22..Engineers and Shipbuilders in Scotland, Institute of, 39, Elmbank Crescent, Glasgow, 7.30 p.m. 1. Mr. R. B. Mitchell, "The Dalmarnock Power Station." 2. Discussion on Paper by Sir W. S. Abell, "The Ancient History of Ship Regulations."

Metals, Institute of, Imperial Hotel, Birmingham. Mr. R. T. Rolfe, "Gun Metal."

Automobile Engineers, Institution of, 7, The Quadrant, Coventry, 7.45 p.m. Mr. T. R. Speck, "The Lay-Out and Design of Engineering Works."

Faraday Society, at the Chemical Society, Burlington House, W., 8.0 p.m. 1. Prof. A. W. Porter, "Some Aspects of the Scientific Work of the late Lord Rayleigh (Presidential Address)." 2. Mr. W. E. Hughes, "The Forms of Electro-deposited Iron and the Effect of Acid upon its Structure. Part I.—Deposits from the Chloride Bath." 3. Mr. S. Field, "The Electrolytic Recovery of Zinc." 4 Prof. A. Findlay and Mr. V. H. Williams, "Notes on the Electrolytic Reduction of Glucose."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Dr. F. G. Crookshank, "The Significance of Mongolian Imbecility."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Mr. J. B. Partington, "British Trade Possibilities in Hong Kong and South China."

Horticultural Society, Vincent Square, Westminster, S.W., 3 p.m. Mrs. Arber, "Some Early Herbals."

Civil Engineers, Institution of, Great George Street, Westminster, S.W., 5.30 p.m. 1. Mr. A. Peake, "The Southern and Western Suburbs Ocean Outfall Sewer, Sydney, New South Wales." 2. Mr. W. E. Bush, "The Main Drainage of Auckland."

WEDNESDAY, MARCH 23..Geological Society, Burlington House, W., 5.30 p.m.

THURSDAY, MARCH 24..United Service Institution, Whitehall, S.W., 5.30 p.m. Lord Riddell, "The Relation of the Press and the Army in the Field."

Pottery and Glass Trades Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John Street Adelphi, W.C., 7.30 p.m.

*For Meeting of the ROYAL SOCIETY OF ARTS, see page 267.

Journal of the Royal Society of Arts.

No. 3,566. VOL. LXIX.

FRIDAY, MARCH 25, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES

PRESENTATION OF THE ALBERT MEDAL TO PROFESSOR ALBERT ABRAHAM MICHELSON.

At a meeting of the Council on Monday afternoon, the 14th inst., Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council, presented to Professor Albert Abraham Michelson, For. Mem. R.S., the Albert Medal of the Society, awarded to him in 1920 for his optical inventions which have rendered possible the reproduction of accurate metric standards and have provided the means of carrying out measurements with a minute precision hitherto unobtainable.

MR. CAMPBELL SWINTON said:—Prof. Michelson, in the unavoidable absence of His Royal Highness the Duke of Connaught, who, as President of this Society, would in the ordinary course present this medal, the duty falls upon myself as Chairman of the Council of the Society.

Perhaps it may not be out of place if, before proceeding to the presentation, I make a few remarks with regard both to the origin of the medal and the origin of this Society, with which you may not be fully acquainted. The Royal Society of Arts, which used to be known as the Society of Arts, was founded as long ago as the year 1754, so that it has reached a certain degree of respectable antiquity. It is, I believe, the second oldest scientific Society in England. The Royal Society, of which you are a distinguished Foreign Member, is much older, as it was founded some ninety years before this Society. It may be of interest to you to know that one of the earliest Members of the Society of Arts was a very renowned fellow countryman of your own, namely, Benjamin Franklin. Many distinguished Englishmen have also been Members of the Society, including some of the best known literary men in the country—Dr. Johnson, for instance, who said on one occasion that when he tried to address the Society his flowers of oratory forsook him; Oliver Goldsmith, who was at one time an unsuccessful candidate for the Secretaryship of the Society, and Edward Gibbon, the writer of "The Decline and Fall of the Roman Empire." Many other distinguished men in various walks of life have been members of the Society, amongst whom I may mention David Garrick, the actor; Thomas Chippendale, who has given his name to a class of furniture; several celebrated painters, including Sir Joshua Reynolds and William Hogarth; and also many statesmen, of whom I will only mention one, William Pitt, the Earl of Chatham.

To-day we are meeting in a room which is part of the building that was erected specially for the Society more than one hundred years ago by the celebrated architects, the brothers Adam, who built the whole of the Adelphi.

The Albert Medal was not instituted until the Society had been in existence for quite a hundred years. It was instituted in the year 1862, as a memorial to His Royal Highness Prince Albert, the Consort of Queen Victoria, and the grandfather of our present King. Prince Albert had been for eighteen years President of this Society, and had taken a great interest in it, so when he died it was thought that a fitting memorial would be to institute this Medal, which is awarded annually, quite irrespective of country, for distinguished merit in promoting arts, manufactures or commerce. There have been up till now 55 recipients of the medal. I do not propose to read the names of all of them, for it is a long list, but I think some will be of

special interest to yourself, as they were very eminent physicists. The first physicist who received this medal was Michael Faraday, to whom it was given in 1866, and other physicists to whom it has been awarded are Sir Charles Wheatstone, Sir William Thomson (afterwards Lord Kelvin), James Prescott Joule, Prof. Helmholtz, Sir William Crookes, Lord Rayleigh, Sir James Dewar, Madame Curie, Sir Joseph John Thomson, Sir Richard Glazebrook and Sir Oliver Lodge. I think those comprise all the physicists who have received this medal, but there have been other very distinguished recipients in other walks of life, as, for instance, physiologists such as Lord Lister, Louis Pasteur and Elias Metchnikoff; chemists such as Liebig, Chevreul, Dumas, Hofmann and Perkin; and engineers such as the first Lord Armstrong, Sir Henry Bessemer, and Sir Charles Parsons, the last of whom I am glad to say we have present with us to-day. It may be of special interest to you to know that you are the fifth citizen of the United States to receive this medal. It was awarded in 1884 to Captain James Buchanan Eads, the distinguished American engineer, and then at later periods it was given to Mr. Edison and to Prof. Alexander Graham Bell, and comparatively recently, in 1917, to Mr. Orville Wright, the distinguished flying machine inventor.

It may also interest you to know that as long ago as the year 1774 this Society was trying to find a natural constant to provide a basis for standards of length. In that year the Society offered a Gold Medal for an invariable standard of weights and measures, but apparently at that time the problem was considered insoluble; at any rate, the Medal was never awarded.

And so we come down to the year 1893, when you, Sir, suggested that the length of the metre might be stated in terms of the wave length of light, while you went on, with your improved Interferometer, and using, as I understand, the red line of cadmium, to show that by that means it was possible to standardise the metre, or any other measure of length, in such a way that, even if all the actual specimens of the standard were lost or destroyed, it would be possible from experiment to reconstitute them with a very great degree of accuracy. I think that the Council of the Society had specially in view your work in that direction when they decided to offer you this Medal, but of course they also had not forgotten your labours in other directions, and especially the remarkable work that you have accomplished with regard to the measurement of heavenly bodies, including those wonderful methods whereby you have been able accurately to measure the dimensions of the giant stars, the diameters of which, I understand, are commensurate with the diameter of the orbit of the earth round the sun, which diameters you have been able to gauge across the vast abyss of space that separates these enormous stars from our little earth.

Prof. Michelson, I have very much pleasure, on behalf of the Royal Society of Arts, in presenting you with the Albert Medal.

PROFESSOR MICHELSON, in replying, said: Without attempting to criticise the Council in awarding this medal to me, I am free to say that I do not consider myself for a moment in the same category as the celebrated men whose names you, Sir, have read, every one of whom I know either personally or by reputation. I feel that I am a very small and insignificant figure beside them. If I have been fairly successful in some of the researches I have carried out, I attribute the matter a good deal to chance, a good deal to fortuitous combinations of circumstances, and a great deal to the assistance of my collaborators, without which it would have been quite impossible for me to put into the form of metal and glass the ideas that I had conceived might possibly some day prove successful.

In conclusion, Gentlemen, I should like to consider that this is as much an expression of your good feeling towards my country as it is to myself. I assure you that that good feeling is heartily and cordially reciprocated, and if ever again you are in trouble you can count on us, whether we have an alliance with you or not, to come to your assistance.

In addition to the Chairman, the following members of the Council were present:— Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.; Sir Steuart Colvin Bayley, G.C.S.I., C.I.E.; Sir Thomas Jewell Bennett, C.I.E., M.P.; Peter MacIntyre Evans, M.A., LL.D.; Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc.; William Henry Maw, LL.D., M.Inst.C.E.; Major Sir Francis Grant Ogilvie, C.B., LL.D.; Hon Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc.,

F.R.S.; Hon. Richard Clere Parsons, M.A.; John Slater, F.R.I.B.A.; Carmichael Thomas; Professor John Millar Thomson, LL.D., F.R.S.; Sir Henry Trueman Wood, M.A.

FIFTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 16th, 1921; THE RIGHT HON. LORD JUSTICE ATKIN in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Hayes-Gratze, E. V., London.
Jennings, Mark, Bury St. Edmunds.
Simpson, Hon. Hubert Ashton Laselve, O.B.E., J.P., Kingston, Jamaica.

The following Candidates were balloted for and duly elected Fellows of the Society:—

Adams, Charles Hubert, B.Sc., A.M.I.A.E., Shinfield, Berkshire.
Gaul, James, Jamaica, B.W. Indies.
Lynch, Hon. James Challenor, O.B.E., LL.M., Barbados, B.W. Indies.
Macnab, Henry Edwin, London.
Marreco, Geoffrey Algernon Freire, Woking, Surrey.
Phillips, Edward George, London.

CANTOR LECTURE.

On Monday evening, March 21st, MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc., delivered the third and final lecture of his course on "X-Rays and their Industrial Applications."

On the motion of the Chairman, Mr. Alan A. Campbell Swinton, F.R.S., a cordial vote of thanks was passed to Major Kaye for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 16TH, 1921.

SIR JOSEPH E PETAVEL, K.B.E., D.Sc., F.R.S., Director of the National Physical Laboratory, in the Chair.

The CHAIRMAN said that Prof. Cramp, who was to read the paper that evening, had been engaged for many years on the investigation which formed the subject of his paper. He had formerly been interested in the professional side of the work, but was now one of the distinguished teachers of a British University. Although pneumatic plant had been in use for some time, he thought the present was the first occasion on which the many interesting problems which arose in connection with the efficiency of plant had been studied, and the whole question investigated with the requisite knowledge and ability.

The paper read was:—

PNEUMATIC ELEVATORS IN THEORY AND PRACTICE.

BY PROF. WILLIAM CRAMP, D.Sc., M.I.E.E.

1. GENERAL.

A pneumatic transport plant is defined as an apparatus in which material consisting of an aggregate of loose particles is caused to travel through pipes or conduits by means of a current of air. Examples of such plants are to be found in elevators and conveyors for grain, ashes and the like, and in systems for the removal and collection of dust, fluff, chips or refuse, etc. Two varieties of such plants may obviously be distinguished, viz., that variety in which the static head of the air in the conveying pipe is below atmospheric pressure and that in which it is above atmospheric pressure. The former are called "suction," the latter "pressure" plants. A third variety is possible, consisting of a combination of these two primary systems. In this case the static head of the air is below atmosphere at the intake end, but above atmosphere at the delivery end.

All such plants depend upon the same general principles; but, except in the case of material like grain, the size and weight of the particles are liable to vary so much as to render even an approximate calculation of the air pressure very unreliable. Experiment alone can dictate the proportions of the plant then. In the case of grain and similar regularly granular materials much more accurate prediction is possible.

2. GRAIN PLANTS.

These have been in use for many years, and many descriptions have appeared in the home and foreign press of typical installations.* Yet notwithstanding this fact

* Hutte, Des Ingenieurs Taschenbuch, 1908 II. 532.
Mitchell, The Pneumatic Handling of Grain: Milling. June, 1914.
Duckham, The Engineer, February 19th, 1897; Engineering, Jan. 29th, 1897.
Bentham, Pneumatic Grain Handling Appliances, Manchester Assn. of Engineers, Nov., 1916.
The Engineer, March 31st, 1916, Oct. 15th, 1915.
The Electrician, Dec. 31st, 1920.

there does not appear to be any published discussion whatever of the principles and calculations involved. Indeed it is not too much to say that had the equations governing their behaviour been properly understood, much expense and many blunders

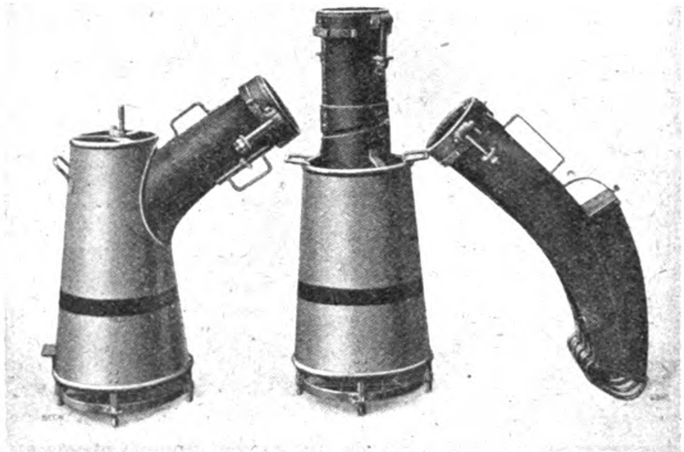


Fig. 1.

might have been avoided. It is to be regretted that most authors seem purposely to have retarded the art by evading the publication of technical information.

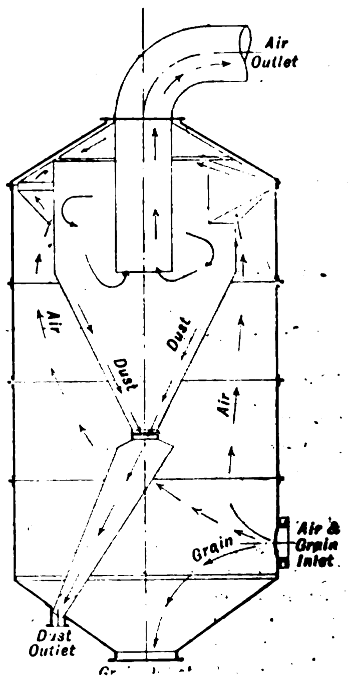
There are at least three firms on the Continent and four or five in England concerned in the manufacture of these plants. I have the advantage of knowing most of these firms, and I think that hitherto their work has been largely empirical. It is also interesting to note that while the system was really invented in England, its subsequent development has been more successfully carried out on the Continent, and it is the European war which has contributed chiefly to renewed activity in this country.

Most of the existing plants are of the suction type. They are used at the chief docks and warehouses for removing grain in bulk. Large floating pneumatic elevators exist at London, Hamburg, Emden, Amsterdam, and a smaller one at Limerick. Fixed plants are to be found at many silos in England and on the Continent.

3. Suction Plants—Essential Parts.

These are six in number, viz.:—

(1) The nozzle which dips into the grain.
(2) The pipes conveying grain and air.
(3) The receiving chamber wherein the grain and most of the dust are deposited.
(4) The air lock whereby the grain, etc., is delivered from the receiving chamber.
(5) The dust filter, which retains such dust as is not deposited in the receiving chamber and prevents its passing into the exhauster.
(6) The exhauster.



'ig. 2.—Receiving Chamber with inside Cyclone.

Of these parts the first two and the last are of primary importance from the point of view of the present paper. The third, fourth, and fifth, while very important to the successful operation of the plant, do not seriously affect its efficiency and lifting power, and will not be considered. It is of course assumed that they are made as air tight as possible, and of a capacity suited to the rest of the plant.

Fig. 1 shews three types of nozzle. It will be noticed that in all cases an adjustable opening is provided at the top. This is called the "auxiliary air inlet" and reference will be made later to its purpose

Fig. 2 illustrates a receiving chamber and Figs. 3, 4, and 5 three types of air lock.

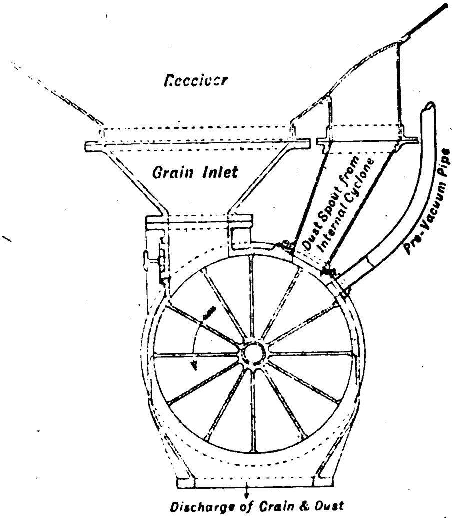


Fig. 3.—Rotary Discharger.

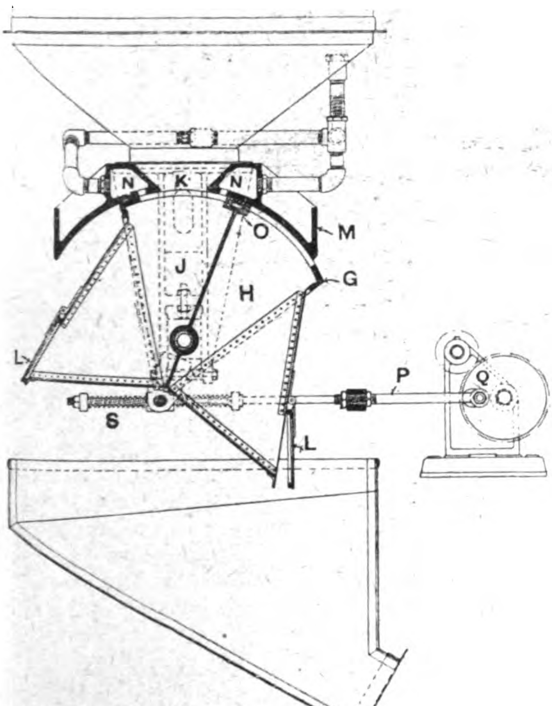


FIG. 4.

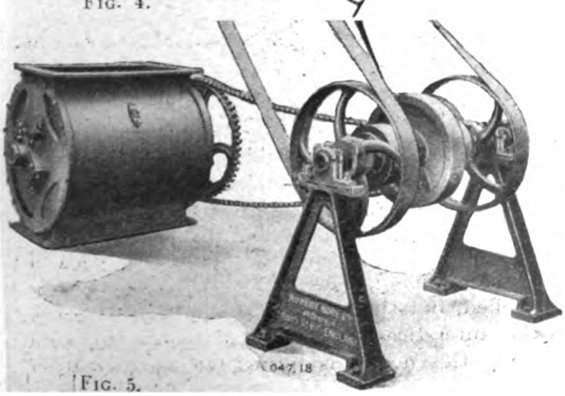


FIG. 5.

One of the great troubles in these plants is the stoppage or breaking of the seal due to pieces of rope, wood, chain, etc., being drawn up with the grain and trapped. This difficulty is overcome sometimes by driving the seal through a friction clutch, which allows the seal to stop until the obstacle is removed. In Fig. 4 the difficulty is overcome by the springs on the push rods S, which allow the oscillating box H to stop until the return stroke when the obstacle is released. Fig. 5

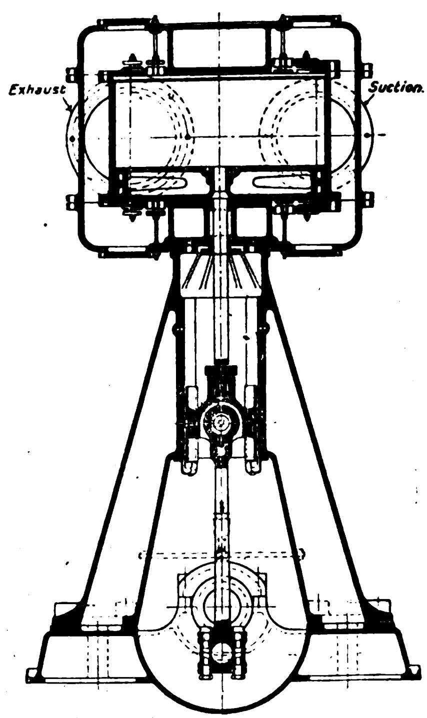


FIG. 6

achieves the same result by automatically reversing the seal through a very ingenious inertia device, consisting of a small fly wheel with double threaded nut. When the seal stops, the wheel continues to revolve, and by means of the nut, transfers the drive from one clutch to another running in the opposite direction.

Figs. 6 and 7 shew two types of exhauster. The first is a pump, the second a turbo-fan. Of these alternatives it should be explained that the first differs from ordinary air pumps in the large inlet and exhaust valve areas required, and that the difficulties with turbo exhausters are twofold, viz.:—the liability of the vanes to cutting by any dust contained in the air, and the large power absorbed when, for any reason the vacuum falls. These troubles, however, have been overcome by special precautions in the design shewn, but the difficulty of attaining a high efficiency with a turbo-exhauster at the vacuum, and with the quantities of air required for these plants still renders their adoption doubtful.

Fig. 8 shews a typical pump diagram.

It will be seen from these illustrations that a great deal of ingenuity has successfully been spent upon the mechanical details of the plant, but I shall presently shew that from the point of view of efficiency there has been an equal neglect of theory and experiment in the general proportions and design.

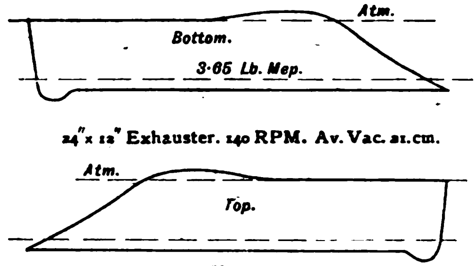


Fig. 8.

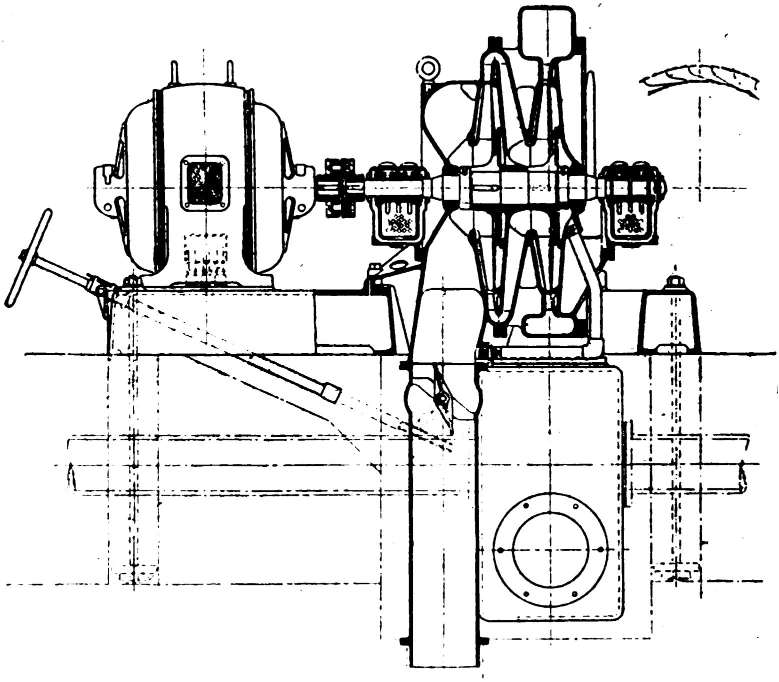


Fig. 7.

4. General Principles.

The action upon which the plant depends may be described as follows:—

A length of pipe terminating in some form of nozzle is connected to an exhauster, and the nozzle is thrust into a mass of grain. This grain is never so closely packed, but that air can be drawn through the interstices between the grains, even when the nozzle is buried to a depth of

several feet. Indeed, it is remarkable to what a great depth the nozzle may be covered without affecting sensibly the quantity of air drawn through the grain for a given difference of pressure measured as between the atmosphere and a point in the pipe just above the level of the top of the grain.

The air as it is drawn through the grain exerts a force upon it, tending to cause the grain to follow the air. In consequence, when the air velocity is high enough, the grains nearest to the surface in the pipe are drawn up with considerable velocity, and the acceleration is continued until the force produced by the air on the grain is balanced by such retarding forces as the weight of the grain and its friction against the sides of the pipe.

The present paper is confined to vertical pipes. The experiments on horizontal pipes, sloping pipes and bends are not yet completed.

5 PRESSURE EXERTED BY THE AIR ON A GRAIN.

The force acting upon the grain will depend upon the relationship between the velocity of the air, the velocity of the grain, and the value of the force acting upon the grain per unit of velocity difference.

Before any equation whatever can be developed, it is necessary to establish this last relationship. In doing so it must be remembered that a very few trials are sufficient to show that the velocity of the air necessary to move the grain at all is always above the limit of steady flow. *i.e.*, the motion of the air is always turbulent.

Certain considerations led me to suppose that the force acting upon any grain would depend upon the square of the difference between the air velocity and the grain velocity; or, in other words, if V_a be the velocity of the air, considered as uniform, and V_g be the velocity of the grain, then the force acting upon a grain could be expressed in the form :—

$$\alpha\ (V_a - V_g)^2$$

wherein α is a factor having the dimensions M/L and dependent upon the density of the air, and the shape and surface of the grain.

These considerations are four in number :

(1) The experiments of Newton, carried out in 1687.

(2) The experiments of Froude (*) with submerged bodies which suggest that so long as the surface is small the index of the velocity in the resistance equation will not depart much from 2.

(3) The resistance co-efficients of grain as published by Baumgartner (†) which will be found to follow the square law exactly.

(4) Experiments performed on bodies falling from the Eiffel Tower. (‡)

(6) DETERMINATION OF α.

Assuming, then, that the force exerted on the grain is $\alpha\ (V_a - V_g)^2$, it is important to know the value of the constant α for the grain which is to be lifted.

The grain used in the tests described later was No. 1 Northern Manitoba wheat, having a density of about 52 lbs. per cubic foot. The average weight of a single grain was about .027 grammes. The following method was used to determine α

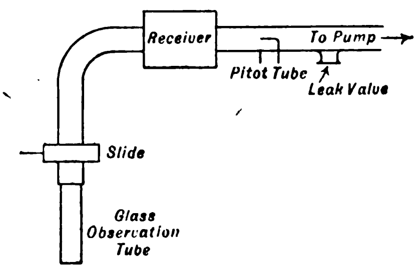


FIG. 9.
Determination of "α." Method II.

A glass tube about 1.16 metres long and 6.55 cms. internal diameter, placed vertically, was attached at its upper end to a pipe leading to a motor-driven vacuum pump. The lower end of the glass tube was open to the atmosphere, and thus a current of air practically at atmospheric density was drawn through the tube. The velocity of this current, V_a metres per second, could be regulated by opening a leak valve near the pump, the velocity being reduced almost to zero when the leak valve was wide open. The velocity was measured by means of Pitot tube I, placed in the position shown.

An air tight slide was placed in the pipe immediately above the glass tube, by means of which the flow of air could be stopped

* See British Association Report, 1874.
† See Mühlenbau I., 1, p. 28.
‡ Comptes Rendus, 1892.

when desired. A receiver was provided at the position shown in the sketch to intercept any grains drawn out of the glass tube and prevent them being drawn into the pump.

repeated until finally a velocity was reached at which all the grains were lifted out of the tube.

The results of the experiments are given below.

TABLE I.

Determination of α for No. 1 Manitoba Wheat, 52 lbs. per cub. ft.
Barom. 75.5 cms. mercury. Temp. 19°C.

Exp.	h reduced to cms. water.	V_a mts. per sec.	No. of grains caught.	Total weight grms.	Weight per grain grms.	α
0	0.28	5.6	All fall out	—	—	—
1	.36	6.3	27	.61	.023	.00058
8	.36	6.3	118	2.38	.020	.00051
2	.45	7.0	79	2.06	.026	.00053
3	.53	7.6	103	3.27	.032	.00055
4	.62	8.3	104	3.46	.033	.00048
7	.66	8.5	83	2.90	.035	.00049
5	.70	8.8	51	1.96	.038	.00049
6	.78	9.3	All drawn up	—	—	—
			Average value of α			.00052

The experiment was carried out as follows:—The air velocity having been adjusted to some low value, a handful of grain was introduced into the glass tube (being blown in from a kind of pea-shooter). The heavier grains immediately fell out at the bottom of the tube; some of the lighter grains were carried up out of the tube; a few grains were left in equilibrium, gently floating about. After a few seconds a tray was placed below the tube and the slide was closed, thus cutting off the flow of air. The floating grains fell into the tray and were weighed and counted, the average weight of one of these grains being thus ascertained. Let this weight be W grammes per grain. Now the force exerted by the air on one of these floating grains must have been just equal to its weight, and hence

$$\alpha\ (V_a - V_g)^2 = W$$

or, since in this case $V_g = O$, $\alpha = \dfrac{W}{V_a^2}$

Thus α was determined for these grains. Beginning with a velocity at which no grains were lifted, the experiment was

The average weight of 1 grain was found to be .. .027 grms.

In discussing the results of the tests of the experimental conveyor, we shall take the average value of W/α with air at atmospheric density to be ·027/.0005 for this kind of wheat.

Hence $W/\alpha = 54$ (for air at atmospheric density)

$\sqrt{W/\alpha} = 7.35$ (for air at atmospheric density)

It should be noted that the experiments just described only determine α for a range of velocities $(V_a - V_g)$ from 6.3 to 8.8 metres per second, and do not prove that α remains constant at higher velocities; it appears, in fact, to be falling slightly as the velocity increases, even within the above range of velocities, and although Exp. 1 appears to give too high a value. In the absence of further knowledge, and for the reasons already stated, we shall assume α to be constant for all values of $(V_a - V_g)$.

In order to show the variations of W and α which may be expected when dealing with different kinds of grain, I give below some values of these quantities determined in a previous research by a method similar in principle to the one described.

TABLE II.

Kind of material.	Velocity to float. mts. per. sec.	α
Maize	9	.00345
Karachi wheat ..	9.8	.0004
Malt	6	.00086
Broken wheat average	4.25	.00021
Wheat Husks ..	1	.00003
Cockle	4	.0002

(7). **Equations of Motion of the Grain.**

Consider a grain of weight W grammes, which is being carried upwards in a vertical pipe with a velocity V_g metres per second by a current of air moving with a velocity V_a metres per second. If the air is at atmospheric density the force exerted by it on the grain will be $\alpha (V_a—V_g)^2$. We will neglect at present any forces exerted on the grain by contact with the walls of the pipe, and the only other force acting on it will be its weight W. Let S be the distance in metres up the pipe which the grain has travelled at any moment, and let us suppose that the grain starts from rest at the lower end of the pipe, so that when

$$S = O, \quad V_g = O.$$

The equation of motion of the grain is,

$$\alpha (V_a - V_g)^2 \quad - \quad W = \frac{W}{g} \frac{d V_g}{d t}$$

where t is the time in seconds from the starting point, and g the acceleration of gravity, in metres per second per second.

The curves in Fig. 10 giving the relation of V_g and S for various values of V_a, have been derived from the integration of this equation.

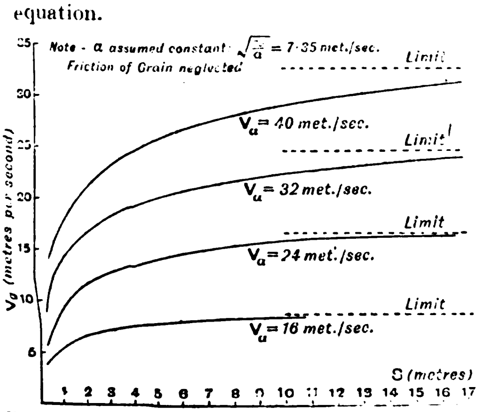


Fig. 10.—Relation between Grain Velocity V_g and Distance S from Nozzle of Vertical Pipe, for various values of Air Velocity V_a (assumed constant)

The general shape of the velocity-distance curve (Fig. 10) should be noted. The grain accelerates very rapidly at the lower end of the pipe, and its velocity finally approaches the limit $V_a—\sqrt{W/\alpha}$ though never attaining this limit.

When this limit is nearly attained, the force of the air on the grain is very little greater than the weight of the grain; for we know this force to be equal to $\alpha (V_a—V_g)^2$, and in this case $V_g = V_a—\sqrt{W/\alpha}$. Hence the grain is now practically in equilibrium, and maintains its velocity with very little further acceleration.

In obtaining these results it was assumed that V_a was constant throughout the pipe. Actually, as the air passes along the pipe its pressure falls and it expands; in a pipe of uniform area, V_a will, therefore, increase the further the air goes along the pipe. For the same reason the density of the air also diminishes, and this probably reduces the value of α.

The general shape of the velocity-space curve, Fig. 10, will not, however, be affected by these modifications as much as might be expected. For we know the force exerted by the air on the grain to be equal to $\alpha (V_a—V_g)^2$; hence, if V_a increases and α at the same time diminishes, it may be that V_g and its acceleration may not be widely different from the case in which V_a and α are constant

If we attempt to integrate the equations of motion, taking into account the changing values of V_a and α the process is much more complicated, as we have to deal with simultaneous equations connecting V_a and V_g with the pressure of the air. As far as can be seen the integration can only be effected by a graphical method. This has been done in a few cases. The chief modification which the exact integration makes to the general *form* of the curves given in Fig. 10 is that $(V_a—V_g)$, after approaching the value $\sqrt{W/\alpha}$ gradually increases again the further the grain travels along the pipe. This might have been expected; for $\alpha (V_a—V_g)^2$ must always be greater than W, the weight of a grain; and as α diminishes indefinitely as the air expands, $(V_a—V_g)$ must increase, if the motion of the grain is to continue.

Besides the above modifications of the simple theory, we must not forget that we have neglected the friction of the grain on the walls of the pipe, which, as we shall see, is generally not negligible. We have

also neglected the fact that the grain reduces the effective area of the pipe and thus increases V_a. To attempt to introduce these further complications would make the integration very laborious indeed; nor, in fact, have we enough knowledge to do so. We shall, therefore, not attempt at present to refine upon the simple case.

8. Experimental Measurement of Grain Velocity.

In order to ascertain whether the equation corresponded with actual facts, an attempt was made to measure the mean value of V_g over a given length of pipe.

Grain was drawn up a vertical pipe about 9 metres long and 6.45 cms. diam., the general arrangement of the plant being as shown in Fig. 11.

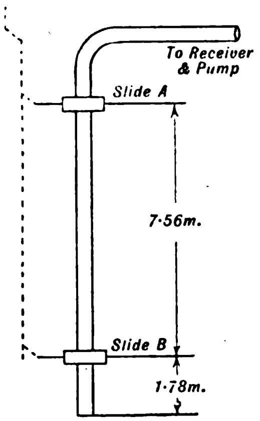


Fig. 12.—Measurement of Grain Velocity.

At the points A and B (Fig. 12) air-tight shutters were introduced, connected together by a system of levers so that both shutters could be closed rapidly and simultaneously, thus trapping between them any grain which might be in the length of pipe A B at the moment of closing the shutters. The plant was started, with the shutters open, and with a certain load of grain passing, which we will call L grammes per sec.

The grain drawn up the pipe was caught in the receiver (see Fig. 11), which automatically ejected the grain from the plant. The rate of lifting was determined in each experiment by allowing the grain to fall from the receiver for a given time into a vessel placed on the table of a weighing machine.

The velocity of the air in the pipe was determined. The slides were then closed and the grain trapped between them was extracted and weighed.

From the weights and times and from the known dimensions of the pipe it is possible thus to deduce exactly the mean velocity of the grain over the given length of pipe.

The results of these experiments are given in Table III. In the last three columns I give the values of V_g at the points A and B respectively and their arithmetic mean, assuming V_a in this equation to be the air velocity at the top of the pipe, *i.e.*, at the point B. It will be seen that the calculated mean value of V_g is usually greater than the experimental value. This is as it should be, for the friction of the grain on the pipe reduces the value of V_g and this has not been allowed for in the calculation; a discussion of this point is given later.

9. Connection Between Velocity of Grain and Pressure of Air.

The fall of pressure of the air as it passes up the pipe is a function of the velocity of the grain. We cannot obtain an exact expression for the relation between these quantities unless we can integrate the equations of motion for the grain, and, as we have already seen, we have not sufficient knowledge to do this unless we make simplifications which are only approximately true. We can, however, consider the general form of the pressure-velocity equation for a vertical pipe.

We know that the change of momentum of air and grain per second in a given length of pipe is equal to the sum of the forces acting on the air and grain in that length.

Now the forces acting on the grain and air are:

(1) The difference in pressure on the column of air.
(2) The friction between the pipe and the grain.
(3) The weight of the grain.
(4) The friction of air on the pipe.

Of these, experiment and theory alike show that No. 4 is almost negligible in all cases. No. 2 only becomes of importance at high velocities.

I was able to measure with some accuracy the friction of the grain on the pipe and to deduce the following expressions for the pressure difference in cms. of mercury in the case of the wheat used in these tests:—

$$p_0 - p = 20.7 \frac{L}{F} \left\{ \frac{V_f}{9.81} + \frac{S}{0.8} \left(\frac{1}{V_f} + \frac{.018}{\sqrt{L}} V_f \right) \right\} + \cdot 0011 V_a^2 \frac{S}{d} + \cdot 00092 V_a^2$$

Where Vf is the velocity attained by the grain at the top of the pipe as given by the expression

$$V_f = V_a \frac{\sqrt{\frac{0.97}{\sqrt{L}} (V_a^2 - 54) + 54}}{1 - \frac{0.97}{\sqrt{L}}}$$

and L = grain lifted in tons per hour.
F = Area of the pipe in sq. cms.
Va = velocity of the air at the top of the pipe (metres per sec.)
S = length of pipe in metres.
d = diameter of the pipe in cms.

To prove that this equation gives approximately correct results under widely varying conditions, Table IV. has been drawn up comparing the calculated with the measured pressures for a series of tests on the experimental plant. The agreement is fairly good and may be expected to hold for pipes of other lengths and diameters provided that the length is not less than 9 metres and that the air velocities do not exceed 40 metres per second and that the vacuum does not exceed 25 cms. of mercury.

TABLE IV.

TABLE OF CALCULATED AND ACTUAL VACUA FOR A PIPE 9 M. LONG AND 4.8 CM. DIAMETER

Tons per hour lifted.	Va. Metres per sec.	Vacuum calculated cms. of mercury.	Vacuum measured cms. of mercury.
1.39	20	7.3	7.2
	30	10.5	10.8
	41	14.8	13.5
2.38	19	10.4	11.2
	33	16.1	16.8
3.72	19	14.6	15.3
	29	19.6	19.6
	37	24.6	23.8
4.85	18	17.7	18
	26	21.9	22.3
	34	27.4	26.4
6.3	27	27.4	27.5

10. THE CONDITIONS WHICH LIMIT THE EFFICIENCY OF A VERTICAL CONVEYOR.

The chief work done by the atmosphere upon the contents of the pipe is the sum of the increase of the energy of the grain per second plus the total work of friction done by the air on the grain per

TABLE III.

Expt.	Load L grms. per sec.	G grms	V B cms. mercury	V_aB metres per sec.	V_gAB metres per sec. (mean)	V_gA calculated metres per sec.	V_gB metres per sec.	$\frac{V_gA + V_gB}{2}$
1	380	1910	9.4	10	1.5	2.2	2.6	2.4
2	350	1080	7.4	11	2.5	3.0	3.6	3.3
3	710	1670	8.6	13	3.2	4.6	5.6	5.1
4	900	1310	9.4	14	5.2	5.3	6.6	5.9
5	1590	1990	12.0	14	6.1	5.3	6.6	5.9
6	1260	1590	12.0	14	6.0	5.3	6.6	5.9
7	1530	2170	12.7	15	5.3	5.9	7.5	6.7
8	510	570	14.0	16	6.7	6.6	8.5	7.5
9	1290	1120	12.0	16	8.7	6.6	8.5	7.5
10	760	810	14.8	18	7.1	7.8	10.3	9.0
11	850	910	13.5	18	7.1	7.8	10.3	9.0
12	1250	940	12.7	19	10.0	8.3	11.2	9.7
13	1320	1060	12.7	19	9.4	8.3	11.2	9.7
14	1180	870	13.5	20	10.2	8.9	12.2	10.5

second and these to a first approximation may be equated to the work per second required to drive the pumps. This we write $P = M + R$. where P = work per second required to turn pump.

M = increase of energy in grain per second.

$$= L \left(\frac{V_f^2}{2g} + S_f\right);$$

Where V_f is the final velocity of the grain and S_f is the vertical height to which the grain is lifted.

R = work of friction between air and grain per second.

$$= L \frac{\alpha}{W} \int (V_a - V_g)^3\, dt.$$

Let E (total) be the ratio of the total energy appearing in the grain to the pump work done to produce it.

$$\text{Then E (total)} = \frac{M}{M+R}$$

Let E (lift) be the ratio of the energy required only to *lift* the grain to the total pump work

$$\text{Then E (lift)} = \frac{L.\ S_f}{M+R}$$

It will be seen that while E (total) is the mechanical efficiency of the vertical pneumatic conveyor, E (lift) may be described as the useful efficiency; for the kinetic energy produced in the grain is not generally made use of.

Whichever efficiency we consider, it is obvious that we should aim at reducing R, the work of friction, as much as possible. If R could be reduced to zero, then E (total) would be 100%. The case is analagous to that of a cable car, drawn by a continuous rope which is constantly slipping in the grip. Work is wasted which is equal, per second, to the force of friction between the cable and grip multiplied by the slip per second. If the slip could be reduced to zero the efficiency of this means of drawing the car would be 100%.

Now in a vertical conveyor we have seen that the "slip" of the air past the grain can never be less than $\sqrt{W/\alpha}$ metres per second, for this is the least velocity of slip which will just sustain the weight of a grain, when no acceleration is taking place.

Hence R. can never be reduced to zero and it is this fact which limits the theoretical maximum efficiency of pneumatic elevators.

If we could start with grain in which the kinetic energy were already produced for us, and had only to consider the efficiency of conveying that grain, we should choose as high a grain velocity as possible. But as most pneumatic conveyors have to produce the kinetic energy in the grain as well as to convey the grain, we should find that though we had diminished R by choosing a high V_g we had at the same time increased M, and we know that the total pump power $P = M + R$. There will, in fact, be some intermediate value of V_g which will make $M + R$ a minimum.

It is clear that the efficiency of a vertical elevator will depend upon the acceleration of the grain in the pipe, and this in turn may be varied by shaping the pipe itself. For instance by making a pipe smaller at the nozzle than at the top the final velocity may be reduced and conversely by making it larger at the bottom the initial acceleration may be reduced. Now the equation connecting the power required to move the grain with the final power in the grain itself may be expressed in terms of the acceleration of the grain and by choosing various accelerations, the maximum theoretical efficiency may be calculated. The results from 4 types of acceleration are shown in Fig. 13. From which the following conclusions may be drawn.

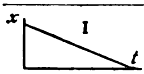
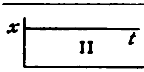
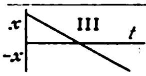
x = Acceleration	Lift (m)	H.P. per ton per hr.	Effy. % Total	Effy. % Lift
	9	·13	33	26
	18	·21	41	32
	9	·14	31	23
	18	·23	38	29
	9	·11	32	32
	18	·17	39	39
	9	·17	29	19
	18	·27	34	25

Fig. 13.—Maximum Possible Efficiencies—with various accelerations.

(1) That long pipes are more efficient than short ones though not in proportion to the length.

(2) That a plant will work more efficiently with light and bulky material than with heavy and compact material.

(3) That the increase in efficiency obtained by the kinetic energy of the grain is small.

It is of interest here to compare these theoretical possibilities with actual results achieved in practice. With a mechanical

bucket elevator the efficiency may be as much as 60 or even 70 per cent., but we know of no pneumatic elevator at present built which has an efficiency exceeding 10 per cent., and more often it is 5 per cent, or even less. It will thus be seen that while theory shows that for wheat we can never expect to exceed 30 per cent., vast improvements upon the present plants are possible. To test this point and to arrive at a method of design a large number of tests were carried out on the experimental plant shown in Fig. 11.

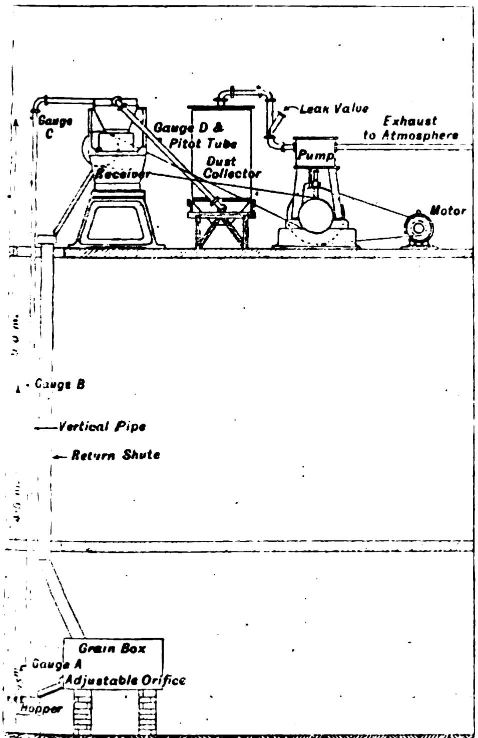


FIG. 11.*

In these tests the pressure differences over the length of the pipe, the air quantities used, the weights of grain lifted and the air leakages were all measured and H.P. per ton per hour was determined.

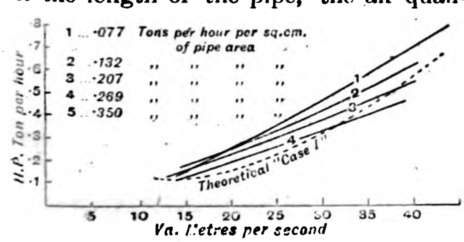


FIG. 14.—Tests of Vertical Pipe 9 metres long 4.8 cms. diameter. Relation between Horse Power per Ton per Hour and Air Velocity, V_A, at Top of Pipe (Wheat $\sqrt{\frac{W}{\alpha}} = 7\cdot35$ Met/Sec.) Air Friction and Acceleration Losses Deducted

Fig. 14 shows the results obtained and compares them with the first acceleration of Fig. 13. It will be seen that the H.P. per ton per hour is less for large loads than for small loads. It will also be seen that at low velocities the agreement between theory and practice is specially good so that the efficiency achieved is of the order of 20%, and in certain cases exceeds this figure It will thus be seen that by proper design efficiencies can be reached in practice which approximate to the maximum possible.

11. DRAWING POWER OF NOZZLE.

We have now to consider a question which is of considerable importance in the design of pneumatic conveyors. We have hitherto been dealing with the efficiency of transmission of a conveyor pipe in which a given load is passing, but we have not considered the question of how that load is introduced into the pipe. We shall find, however, that for any given air velocity in the pipe, there is a definite limit to the load which will be drawn into the pipe in a given time through any particular form of nozzle. Suppose we have a conveyor pipe through which air is passing, the velocity of the air at the nozzle being sufficient to lift the grain; Let the nozzle be plunged below the surface of a mass of grain. The grain immediately adjacent to the nozzle will be rapidly accelerated and carried into the pipe, leaving a partial cavity round the nozzle. Into this cavity the surrounding grain falls from all sides, but most freely from above, under the force of gravity. For any given velocity of the air at the nozzle, it will be found that a definite weight of grain per second per unit of area of nozzle is drawn into the pipe. It would appear that the factor which limits the amount of grain drawn in is the rate at which the grain can fall under the action of gravity towards the nozzle, for a nozzle placed in a horizontal position will draw more than the same nozzle placed vertically. The flow of grain towards the nozzle was studied by making one side of the grain box of glass, and placing the nozzle close to the side. In the case of a vertical nozzle most of the grain descends vertically to the nozzle by a path close to the side of the pipe. The motion is suddenly reversed at the nozzle and the grain drawn upwards into the pipe. In order to effect this reversal

of motion quickly, a strong current of air is required at the nozzle. With a horizontally placed nozzle the "stream-lines" followed by the grain have much less curvature, and the grain flows into the nozzle with less assistance from the air.

12. TESTS OF NOZZLES.

A few tests with various forms and positions of nozzles were made with practically the same apparatus as that shown in Fig. 11, but in some of the tests the vertical pipe and nozzle together were only about 2 metres long. The nozzle was placed in a large box full of grain, and was allowed to draw all the grain it would take in. The load taken was measured by catching the grain falling from the receiver in a given time, and weighing it.

The tests were not exhaustive but they are sufficient to shew that for each type of nozzle the ratio, or nozzle constant

$$\eta = \frac{L}{Fo\ Vao}$$

where Fo = the area of the nozzle in sq. cms. and Vao = the velocity of the air at the nozzle calculated on Fo, is approximately constant; and that it has an extremely important bearing on the design and performance of the plant. Indeed I find that the following expression is very nearly correct

$$\frac{L}{F} = \eta \left(1 - \frac{p_o - p}{p_o}\right) V_a$$

This equation may be taken in conjunction with that given on p. 291, as a basis for the design of new plants. From these the corresponding H.P. per ton per hour can also be derived, and this is a satisfactory method for designing a plant with an appropriate nozzle. On some future occasion I hope to go into this matter more fully. It is sufficient to say here that the tests shew the inefficiency and uselessness in many cases of the auxiliary air inlet which is a feature of all existing commercial plants; and they further shew that up to a load density of 0.35 tons per hour per sq. cm. of pipe area, which is a far higher load than that met with in practice, no choking nor instability of any kind was experienced.

The experiments prove therefore five things:—

(1) That the proper method for the design of a pneumatic elevator is by means of the equations given above.

(2) That when this method is adopted the only excuse for an auxiliary air inlet is the desirability of keeping the vacuum within certain limits to avoid undue leakage and air pump friction.

(3) That pneumatic elevators may be built of smaller dimensions than heretofore.

(4) That their efficiency may be increased from 5 or 10 per cent. to 20 per cent.

(5) That the gain to be expected from taper pipes is relatively small.

It is hoped that this research may prove both a stimulus and a guide to English makers of pneumatic plants, and that the work here set forth may enable them to take the lead in scientific design.

I cannot conclude without mentioning with gratitude the grant made towards this work by the Department of Scientific and Industrial Research, the hospitality and sympathetic help of Sir Joseph Petavel, who placed his laboratories at my disposal in Manchester, the large share taken in the work by my assistant, Mr. Adam Priestley, M.Sc., and last, but not least, the present of the complete plant shown in Fig. 11 by Messrs. Thos. Robinson and Sons, Rochdale.

DISCUSSION.

The CHAIRMAN (Sir Joseph E. Petavel, K.B.E., D.Sc., F.R.S.) said he was sure that many of those present were greater experts than he was on the question of the practical manipulation of grain. He would, therefore, not delay the discussion by very lengthy remarks, but felt compelled to express to Prof. Cramp his admiration at the very systematic way in which he had developed his study of the subject over a series of years, and finally arrived at a clear understanding of the various points on which design depended. Everyone would agree, he thought, that Prof. Cramp's students were to be envied, because the author had the rare talent of being able to pass gently over formulæ, and leave an impression of facts behind. The data derived from the experiments which had been described, if wisely applied to present design, might greatly increase the efficiency, and incidentally the convenience of, manipulation, of pneumatic elevating plant. The possibility of decreasing the size of the ducts without impairing the efficiency, which the author had shown to be practicable, was very important. One of the chief troubles at present experienced with pneumatic plants was due to the large size of the ducts, which rendered handling awkward, and made it difficult to keep the various joints tight. The whole subject was of very great practical importance.

MR. R. E. KNIGHT said that, in common with the rest of the audience, he had listened to Dr. Cramp's paper with very great interest. He did not think he could usefully add to what the author had said.

MR. MARK JENNINGS (Messrs. Boby, Ltd.), said the author had shown, amongst other tables, figures for the h.p. per ton obtained over periods of six months, which were not similar to those obtained in the shorter tests. It must be remembered that the figures obtained over a period of six months included time spent in cleaning up the floors of barges, running light, etc., and it was that which accounted for the variation. Regarding the impracticability of maintaining high vacua in commercial plants, namely, that it was not simply a question of mechanical efficiency, but the difficulty of keeping an even feed into the pipe. He could not help thinking that very much more fluctuation than was now experienced in pneumatic conveying would inevitably result with vacua much exceeding 25 to 30 c.m. of mercury.

MR. A. G. BULL said he had heard of plant being installed for the double purpose of lifting both grain and coal He would like to know if the efficiency would be the same whichever of those products was dealt with.

MR. ROLAND H. BRIGGS thanked Prof. Cramp for his paper. The author's name would go down to posterity as one who made two grains of corn go where one went before! If from the work which Prof. Cramp had carried out it became possible to get double the efficiency at present obtained from pneumatic elevators, any disadvantage now attaching to them would be removed. Some illustrations of German machines had been shown on the screen. Whatever might have been the efficiency of German machines twenty, or even ten, years ago, enormous strides had since been made in this country. As an example of that progress, he might say that some six weeks ago he received a cable from America, asking him to obtain articles and illustrations relating to British practice in pneumatic conveying, particularly of grain. When the United States wanted information it was always with regard to the most modern practice. A series of articles on pneumatic elevators, which recently appeared in an American technical magazine, contained no less than nine illustrations of well-known English plants.

PROF. CRAMP, in reply, agreed with the Chairman as to the importance of keeping the ducts as small as possible. As at present constructed, if a pipe slipped and hit a man a bad accident might result. One object of the research he had carried out was to find whether smaller pipes could not be used, and he thought he had proved that they could be. Mr. Jennings was correct in pointing out that it was not clear, in the table showing the h.p. per ton over a period of six months, that the figure there given—.96—was not comparable to that obtained in the test—.7—as the former included, as he ought to have pointed out, time spent in what was known as "cleaning up," and other periods during which time and power were wasted. The discrepancy therefore, did not mean that the plant was not working up to its maximum efficiency, but simply that it could not always be used under the best possible conditions. With regard to his query as to the difficulty of maintaining a high vacuum, Mr. Jennings was probably thinking of leaks in the valves, seals and pipes. In view of what makers had already done in the way of improving vacuum pumps, etc., he did not think such difficulties were to be feared, and, at any rate, they should not deter manufacturers from attempting to reach the figures he had given in the paper. He did not say those figures could be reached, but they could be more nearly approached than was at present the case. With regard to Mr. Bull's question, experiments showed very clearly that the efficiency of a plant depended on the quality of the material with which it was dealing. Coal had a higher specific gravity than grain, and was far more irregular in shape, so that he could not believe it possible to obtain the same efficiency with coal as with grain. All wheat was more or less the same size, but the size of pieces of coal varied considerably. He knew some makers were developing plants for use with coal, and when in Germany in 1912, he had seen coal transported pneumatically from the road, over the roofs of some offices, to a factory behind—in all about 50 yards. There was no reason why similar work should not be done in this country. England was now ahead of Germany in the manufacture of pneumatic plant, and could maintain that lead, but not on the lines adopted before the war. Eleven or twelve years ago he remembered hearing the Managing Director of a large English company tell a young man in his employ, who was working very hard at figures and equations similar to those he himself had dealt with in the paper, that he was wasting his time, and that if he wanted to do work of that sort he should do it at home! The efficiency of a plant depended to a large extent on the material with which it dealt; a plant would be more efficient when lifting malt than wheat and so on. He was very pleased to hear what Mr. Briggs said about America coming to England for information. It was certain that this country led the way in the manufacture of pneumatic plant at the present time. The experiments he had carried out had been financed partly by the State—by the Department of Scientific and Industrial Research.

He himself had given his time, Mr. Priestley had done a great deal of work, Sir Joseph Petavel had lent his laboratories, and Messrs. Robinson had given plant. But from what he had said that evening the results of his experiments would become widely known, and the Americans would not be slow to take advantage of them. If this country was to maintain her lead, therefore, she must work hard to that end.

THE CHAIRMAN proposed a very hearty vote of thanks to the author for his paper. He thought the paper provided a typical instance of the useful purpose which the Royal Society of Arts served in bringing new ideas and new information to the attention of those likely to be interested, both by means of the meeting and through the *Journal*.

The vote of thanks was carried unanimously, and the meeting then terminated.

MR. G. F. ZIMMER, A.M.Inst.C.E., writes:—
While the calculations of the author are unquestionably most interesting, I am somewhat afraid that, owing to the fact that the complex underlying principles of the pneumatic system are, as yet, so imperfectly understood, we shall have to rely still greatly upon empirical data.

Judging from the vastly differing nature of the suction plant now installed by different engineers, we are, it appears, a long way from standardization, and it is my belief that the lack of information given by writers on the subject is not so much due to secrecy as to a certain amount of caution in ventilating their ideas as regards principles and calculations.

With regard to power consumption, greater strides have been made, and whereas in the earlier installations it took as much as 5 h.p. and more per ton of grain handled, under average circumstances, it takes now only 1½ h.p. for the same work, and sometimes even less.

Co-operation and exchange of experiences would be a great help in the development of pneumatic handling, and the author's careful calculations form a valuable addition to the literature.

A Continental expert, H. Klug, has made very exhaustive investigations on this subject, and the résumé of these are embodied in an article by the present writer, which appeared in "Engineering and Industrial Management," under date of December 18th, 1919.

Mr. Klug asserts that power consumption and capacity of a pneumatic grain handling plant depends upon the specific gravity of the grain, its form and even the position of the centre of gravity of the individual grain, on the texture of its surface, the degree of moisture it contains on the circumstances whether or not it has become heated during transit, and on the nature of the impurities mixed with the grain. Identically the same installation will, for instance, handle clean Bohemian Barley at the rate of 15 tons per hour, and a power expenditure of 1.5 h.p. per ton for a distance of 100 metres, and to an elevation of 15 metres, while Algerian barley containing sand, earth and small stones, and the husk of which is rough, is only handled at the rate of 10.5 tons per hour, and an expenditure of 2.45 h.p. per ton, a difference of 53 per cent. on the self same plant.

Further variations are also due to climatic conditions in different seasons of the year, find with identically the same variety of grain, auctuations have been recorded at 15 per cent., between capacities in winter and mid-summer, with practically the same power consumption.

Other diversities depend upon the design of the suction nozzle, air pumps, size of pipes, receiving tanks, filters, etc.

From the diagram which accompanied the above mentioned article in Cassier's Magazine, which shows the most favourable power consumption and the vacuum, for handling grain for distances of from 25 to 400 metres, it may be seen that while for a distance of 25 metres, and with a vacuum of 2 inches the power expenditure per ton of wheat handled is only 1 h.p. For a distance of 200 metres, a vacuum of about 12 inches is required with a power expenditure of about 2¼ h.p., and for a distance of 400 metres a vacuum of 30 inches is necessary, with an expenditure of power per ton of wheat handled of 6 h.p. This diagram has been compiled from data of pneumatic plant by most of the principal makers, collected over a long period and under all sorts of conditions. For malt the conditions are even more favourable, while for oats they are less so.

The quantity of grain to be conveyed by a unit of air depends on the diameter of the pipe, the speed of the air, the vacuum, the temperature, degree of moisture in the grain and the percentage of dust. Experience accumulated under close observation from actual practice is the best and only reliable guide, according to Klug. He also says:—Purely scientific considerations and the most elaborate calculations do not lead to reliable data for the construction of plant, as the whole flowing and floating grain dust and air mixture, under gradually increasing vacuum is likewise gradually gaining in speed in the pipes. There are, further, considerations of frictional conditions which are too complex; our main support must, therefore, be empirical data.

I submit these matters to the author's notice, and should be much interested to hear his views.

Pneumatic conveying is, in my opinion, unquestionably an ideal solution for handling all such materials and for such distances for which it is economically applicable. Most, if not all, failures nowadays are due to the fact that pneumatic installations have been pressed

into service where other appliances should have been chosen.

The principal advantages of this system are, that the material never comes in contact with the multiplicity of mechanical parts which are, for instance, in evidence in all types of chain elevators and conveyors, where the device is worn out by the material and where the material is deteriorated by disintegration by the conveyor. This refers particularly to minerals. The pneumatic conveyor is also the only continuous working device of the kind which can pick up material from a plain floor. (The only other handling device which will do this is the lifting magnet which is an intermittent device and confined to magnetic material.) Bucket elevators can, for instance, be lowered into a pile of grain or coal and will remove this to the extent of forming a crater, the apex of which is a foot or so above the floor level. In order to remove the rest, trimming, mechanical or by hand, will be necessary. It is also unavoidable in most installations of ordinary elevators and conveyors, to place the receiving terminal a few feet below the receptacle from which the material is to be removed, which frequently means excavations involving sometimes considerable cost, and at the best, such terminals are in inaccessible positions. The suction pipe nozzle, which constitutes the receiving terminal of the pneumatic plant, and which is located at the end of a flexible pipe, is a most convenient and easily manipulated device. It is true that the pneumatic system is not as positive as a mechanically worked device, but it is on that account more flexible.

YACCA GUM INDUSTRY OF SOUTH AUSTRALIA.

Prior to the War the gathering and shipping abroad of South Australian yacca gum was an important industry on Kangaroo Island, just off the south coast of this State. As Germany was the largest user of this product, the industry was suspended during the first years of the War, and not uutil use had been found for it in the United Kingdom and in America during the latter part of 1916 did the production revive. In 1919 more than 10,000 tons were gathered, and as the Australian consumption is small the greater part of the output was shipped to Great Britain and to the United States. It is believed, writes the U.S. Consul at Adelaide, that further experiments in the use of this valuable product may develop a larger scope for its utilisation and thus encourage the expansion of the industry at Kangaroo Island.

Before the War nearly two-thirds of the Australian output was bought by German firms. Local dealers have never been able to discover what use the Germans put it to, but it is believed that it was used in the manufacture of furniture polish and lacquer for metal ware. It should not be overlooked, however, that the product contains a high percentage of picric acid on nitration, and it is not unlikely that it was also used by the Germans in the manufacture of explosives—a use to which it was put by the Allies in 1917 and 1918.

The gum from the species *Xanthorrhoea Hastilis* is, of course, one of the oldest known sources of picric acid, yielding about 15 per cent. by treating the gum with strong nitric acid. The gum has also been used in the manufacture of dyes. To quote a technical report on the subject, "the high yield of picric acid on nitration and of paraoxy-benzoic on alkaline fusion indicates a chemical constitution for the resin of an oxygenated benzine derivative, and among such derivatives are numerous fine chemicals in daily use, *viz.*, photographic developers and material used in the preparation of synthetic dyestuffs. The resin is also said to be of considerable importance in the manufacture of linoleum."

Experiments have shown that the gum is soluble in alcohol, but insoluble in turpentine, linseed oil, benzine, molten paraffin, and hydrocarbon solvents generally. The gum is partially soluble in cold strong suplhuric acid to a deep red solution; on dilution of the sulphuric acid solution and cleaning the brownish red solid separates. When filtered and freed from the sulphuric acid, this solid dissolves in water and is reprecipitated from its aqueous solution by the addition of a little sulphuric acid.

CULTIVATION OF THE OPIUM POPPY IN ANATOLIA.

Previous to the War, the opium poppy was grown in considerable quantities in the hinterland of Samsun. The principal towns in the Sanjak or Province of Samsun which were engaged in the growing of this plant are Hadji-Kioi, Marsovan, Amassia, Djorum, Zile, Yosgat, Tokat, and Niksar. These towns use Samsun as a port of shipment to Constantinople and European ports.

Planting takes place usually in the month of January, and six months must elapse before the plant develops and reaches a height of approximately 3½ to 4½ feet. Towards the end of May buds appear on the plant, and the end of July finds it completely matured. The buds are then slit and opium in liquid form is withdrawn, which is allowed to dry, and is then exported in round-shaped balls preserved with leaves. After the liquid opium has been completely withdrawn from the bud, which is allowed to remain on the plant, a new period of ripening sets in; the paste which remains in the bud, after the liquid opium has been withdrawn, dries and becomes granulous.

The buds are then picked and the grains are withdrawn. These are poppy seeds and are either white, blue, or "bigarres" (greyish) in colour.

Poppy seeds are purchased by Samsun export commission agents from the various centres of production in the interior and are sent to the coast on the backs of horses, oxen or camels. Arriving at Samsun, they are never altogether free of foreign matter, and the reliable exporter is careful to have his shipment cleaned in accordance with the requirements of his consignees, or the market to which he usually ships. Previous to the War, Germany, Austria-Hungary, France, and the United States were the chief importers of Anatolian poppy seed. The first three countries named made no distinction between blue and white varieties, both being equally in demand. Curiously enough, the United States only provided a market for blue seeds, seeming never to be interested in white. According to the opinion of local shippers, this preference on the part of the United States is only one of habit or custom, as there is absolutely no difference between the two kinds of seeds.

During the years immediately preceding the War, production had greatly developed, and had attained approximately 6,000,000 lb. for export per annum. Stocks of poppy seed were greatly reduced by local consumption during the war, having been largely used for edible and lamp oils. Moreover, the 1919 crop was much less in quantity than in pre-war years. It is expected, however, writes the U.S. Consul at Samsun, that as soon as Turkey finds itself on a peace footing, this industry will rapidly assume its former importance.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m. (unless otherwise announced):—

April 6.—Archibald Barr, LL.D., D Sc., Emeritus Professor of Engineering, University of Glasgow, "The Optophone—an Instrument for Enabling the Blind to read Ordinary Print." (A Demonstration of the Instrument will be given.) Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the Chair.

April 13.—Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Low Temperature Carbonisation and Smokeless Fuel." Sir Arthur Duckham, K.C.B., M.Inst.C.E., in the Chair.

Indian Section.

At 4.30 p.m.

Friday, April 22.—Lieut.-Colonel Sir Edward W. M. Grigg, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

Tuesday, May 3.—William Raitt, F.C S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

Friday, June 10.—Sir George Seymour Curtis, K.C.S.I., "The Development of Bombay."

Indian and Colonial Sections.

(Joint Meeting.)

At 4.30 p.m.

Friday, May 27.—Sir Charles H. Bedford, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

Sir James P. Hinchliffe, "Research in the Wool Industry."

Sir Herbert Jackson, K.B.E., F.R.S., "Research in Scientific Instrument Making."

John Francis Crowley, D.Sc., B.A., M.I.E.E.

Dr. C. M. Wilson, "Industrial Medicine."

William Arthur Bone, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

Cantor Lectures.

Samuel Judd Lewis, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry" Three Lectures.

Syllabus.

Lecture I.—April 11.—Visual and Photographic Methods — Emission Spectra — Flame, Arc and Spark Spectra, as applied to the analysis of complex substances. Comparative methods —Qualitative and Quantitive methods Vacuum tube Spectra.

Lecture II.—April 18.—X-ray Spectra. Spectrophotometers, especially Sector-spectrophotometers for exploring the Ultra-violet region. Absorption spectra by old and new methods.

Lecture III.—April 25.—The significance of Absorption spectra. Studies on the Ultra-violet absorption spectra of Blood Sera, Uric Acid, Cellulose Films, etc. Applications of Spectroscopic Instruments to the technological study of Fluorescence in Paper, Textiles and other materials.

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FRIDAY, APRIL 1, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, April 6th, at 8 p.m. (Ordinary Meeting). ARCHIBALD BARR, LL.D., D.Sc., Emeritus Professor of Engineering, University of Glasgow, "The Optophone—an Instrument for Enabling the Blind to read Ordinary Print." (A Demonstration of the Instrument will be given.) ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

EXAMINATIONS.

The number of entries received for the first or Easter examination, which commenced on March 14th and finished on the 23rd, is 16,658. This is 1,026 less than the number received for the corresponding examination of last year when there were 17,684 entries. The second or Whitsuntide examination will begin on May 2nd and finish on May 11th. The last day for receiving entries is Monday, April 4th.

PETER LE NEVE FOSTER PRIZE.

The late Mr. Reginald Le Neve Foster presented the Society with a donation of £140 for the purpose of founding a prize in commemoration of his father, Mr. Peter Le Neve Foster, who was Secretary of the Society from 1853 to 1879.

The Council have resolved to offer the Prize for a Paper on "The Mineral Resources of China."

The Prize will consist of a sum of £10 and the Society's Silver Medal.

The Paper for which the Prize is awarded will be read at one of the Ordinary Meetings of the Society.

Intending competitors should send in their Papers not later than December 31st, 1921, to the Secretary of the Royal Society of Arts, John Street, Adelphi, London, W.C. 2.

The Paper must be type-written. It may be sent in under the Author's name, or under a motto, accompanied by a sealed envelope enclosing the name, as preferred.

The Judges will be appointed by the Council.

The Council reserve the right of withholding the prize or of awarding a smaller prize or smaller prizes, if in the opinion of the judges nothing deserving the full award is sent in.

PROCEEDINGS OF THE SOCIETY.

TRUEMAN WOOD LECTURE.

WEDNESDAY, FEBRUARY 23RD, 1921.

In the unavoidable absence of the Right Hon. Sir Arthur Griffith-Boscawen, Minister of Agriculture, the Chair was taken by LORD BLEDISLOE, K.B.E.

THE CHAIRMAN, in opening the meeting, said that research and the economic lessons derived from it were a much surer foundation upon which to build a prosperous agriculture than Acts of Parliament, Departmental Orders, or even Government promises. The selection of Sir Daniel Hall to deliver the Trueman Wood Lecture was a recognition of the paramount present-day importance of the greatest industry of the country and also a tribute to his eminent services in the field of agricultural research. Sir Daniel Hall was a worthy successor of Sir John Bennet Lawes and Sir Joseph Gilbert at Rothamsted. He was the most experienced of the Development Commissioners and the one who most fully interpreted the true intent and purpose of the Development Act. He was now the Chief Scientific Adviser of the Ministry of Agriculture, and, as such, the chief director of the activities of the various agricultural research stations and of the brilliant little army of investigators whose services those stations were fortunate enough to command. He (the Chairman) was reminded on the present occasion of the fact that Sir Daniel's appointment as a Development Commissioner was due

to a deputation from the Central Chamber of Agriculture and other leading agricultural organisations which about eight years ago he himself introduced to the present Prime Minister, who was then Chancellor of the Exchequer. He thought it would be generally agreed that it would be difficult to enumerate the benefits which had accrued to agriculture and to every branch of the agricultural community from that appointment. At any rate, no one was better equipped to speak with authority and conviction upon the subject of the organisation of agricultural research than Sir Daniel Hall.

The lecture delivered was :—

THE PRESENT POSITION OF RESEARCH IN AGRICULTURE.

By Sir Daniel Hall, K.C.B., F.R.S.,
Chief Scientific Adviser and Director General of Intelligence Department, Ministry of Agriculture.

The organisation of research applied to agriculture may be said in this country to date from the setting up of the Development Commission in 1909, prior to which time continuous research had been unrecognised by the State. The Rothamsted Experimental Station, founded in 1843, and created a public trust in 1889, had indeed single handed contributed a very large proportion of our earlier knowledge of the nutrition of the plant, but had always been entirely dependent upon the endowment provided by Sir John Lawes. In addition to the work at Rothamsted investigations had also been conducted at the Woburn Station of the Royal Agricultural Society under the late Dr. Augustus Voelcker and his son, Dr. John Augustus Voelcker. Again, members of the staffs of the various Agricultural Colleges and Departments, which had grown up from 1890 onwards, had begun investigations in many directions, but the financial assistance accorded by the State to work of this kind did not amount to more than a few hundreds a year. The Development Commissioners in their Act were expressly charged with the promotion of research and forthwith proceeded to formulate a scheme upon the lines of which work now proceeds. The principle at the base of their scheme was the division of the field of research up by subjects and their establishment at various centres, as a rule in conjunction with a University, of Institutes, each charged with the fundamental research dealing with one particular branch of the subject. Three main reasons weighed with the Commissioners in adopting this form of organisation :—

(1) Research was thereby removed from immediate State control.
(2) Concentration of effort was ensured and overlapping and duplication avoided.
(3) Each Institute could work out a continuing scheme of research and deal with the subject as a whole.

The question of whether research in agriculture, as in other subjects, shall be directly organised under the State, or at one remove under Universities and kindred bodies, is one that has been often and hotly debated. On the one hand from the purely administrative view it is argued that, in so much as the State pays, the State ought to control the expenditure, even in detail. Again, in many cases a Government Department has for its own purposes to obtain information, a process which involves investigation, and it naturally desires to ensure that the Research Institution will get on with the business of providing this particular kind of information.

But when one considers the nature of research, the slowness and irregularity with which results of visibly economic value accrue, the remoteness of its methods from those of a public department, and particularly the character and personality of the men who distinguish themselves in research, it will be generally agreed that the looser system of control prevailing in a University is the more appropriate. The true investigator is always somewhat anarchical in temperament, his work is apt to be continuously destructive of accepted opinions and established reputations. Within a Government Department there is a well defined succession of authority, and when the Department takes an official point of view it is inclined to insist on this opinion being respected and not criticised by the officers on the strength. It has happened within recent years that a scientific man in Government employment has had to choose between his salary and his conscience, and though University laboratories are not always temples of free thought, their atmosphere is distinctly more open than that of a Government office. The type of man wanted for research is more attracted to a University than to a Department, desiring as he does, that his value shall be measured by the quality of his scientific work and not by his adaptability to the routine of an office. An even greater objection to making re-

search a direct function of a Government Department is that thereby the programme of investigation has of necessity to be subjected to an annual detailed justification to administrative and legislative bodies possessing no expert knowledge. It may be agreed that expenditure on research must be criticised and in the end justified by its results, but a considerable measure of faith and patience is needed. At any given moment a great deal of the work that has to be done by a Research Institute can show no immediate practical outcome, but consists in making or improving the methods by means of which the attack on economic problems is to be made. It has been seen in other countries how the annual call for a cash justification of the expenditure of the State Research Departments has had a destructive effect upon the character of the work and the morale of the investigators. For these general reasons the Institutes set up under the scheme for Agricultural Research were attached to the Universities and kindred bodies, instead of being made parts of the Department of Agriculture.

Granting, however, that research is thus in the main a function of the Universities and kindred bodies, Government Departments will still require laboratories in which a considerable amount of investigation goes forward on subjects concerning which a Department has to take action. For example, the Ministry of Agriculture has to administer laws and regulations dealing with animal diseases, and in order to carry out this work with due enlightenment it is desirable that the Department itself should constantly be subjecting the methods of dealing with these particular diseases to investigation. It must possess a research laboratory in which to check the conclusions upon which its administration is based, even though to this official institution the sole responsibility for research in animal diseases is not entrusted.

A second advantage which comes from the association of the Research Institutes with the Universities lies in the informal co-operation that is thereby ensured with the other workers in the field of pure science. In agriculture in particular the problems that arise are most complex, and no institution for research in some particular economic direction can afford to equip itself with all the men from whom it may at times require assistance. For example, soil problems extend into the domains of physical and organic chemistry, even of pure physics and mathematics; nutrition investigations may equally require the help of the pure chemist or physiologist. Now the worker in a University may enlist the advice, and even the active co-operation, of men in the pure science departments in a manner that would be difficult in a self-contained institution. Again, even from the purely scientific point of view many of the most fruitful lines of research are those suggested by practical life. Many results which have afterwards proved to be of fundamental importance to theory only became apparent in the large scale working of the practical man. The association, therefore, of an institute for research of an economic character with a University reacts advantageously on the departments of pure science.

Lastly, if agricultural research is to remain alive it must continuously be kept in contact with the business of farming, and this contact is more readily attained by the association of the research institute with a University which is teaching agriculture and dealing with the farmers of its district than with a Government Department.

If it be granted that in the main the conduct of agricultural research ought to be in the hands of Universities there are still two alternative methods of control. One method is that which has been adopted by the Medical Research Committee, *i.e.*, to set up a central co-ordinating board predominantly of an expert character. This Board surveys the whole field, draws up a programme of investigation, allocates the work to individuals in the Universities and kindred Institutions, and provides the funds necessary for its prosecution. The Central Board thus assumes the direction and co-ordination of effort of a team of workers and concentrates their efforts towards a common end with the avoidance of waste and overlapping. This method was possible in dealing with medical research because there already existed in the hospitals and medical schools all over the country a large body of men engaged in research or capable of being so employed if the opportunity were provided. Such a body of workers in agricultural research had, however, to be called into existence. The material for the co-ordinating activity of the Central Board did not exist. Again, medical research is dealing practically with

one organism, the human body, and though the methods of attack of the pathologist, the physiologist and bacteriologist are diverse they all have a common aim and can be aligned to a common end. Agricultural research, however, embraces a number of subjects which have little in common. The men working upon the nutrition of animals have little to do, either in their methods or their objects, with the investigators of soil problems or with the students of the diseases of plants. What was sought to be attained under the scheme adopted by the Development Commissioners was the setting up of this kind of team work within the limits of each Institute; for example, an agricultural chemist working single handed, is unable to cope with the many complex problems presented by the soil, and a form of organisation which would merely give grants to individual chemists attached to various Institutes who were desirous of working upon soil problems could only attain limited results. The intimate co-operation of a team of chemists, botanists, physicists and bacteriologists, all working jointly at the soil problems, can only be attained in an institution specially dedicated to research upon the soil. On these grounds our agricultural research scheme has been organised by subjects rather than under a single controlling committee. It may be admitted that some form of higher coordination between the various Institutes may become necessary as the body of workers grows, but as will be seen later, this is being provided in the scheme we have under consideration. Again, it may be argued that the organisation of the field of agricultural research into Institutes for specific purposes with the concentration of the funds available for that subject at the Institutes may amount to a certain warning off of other workers who have ideas and could advance the subject were they free to deal with it, but this rigidity in the organisation has been tempered by the simultaneous setting up of a special fund from which these individual workers can draw assistance.

The Institutes that have already been established under the Scheme discussed above may be set out as follows:—

1. Soil and Nutrition of Plant at Rothamsted.
2. Plant Pathology at Rothamsted.
3. Animal Nutrition at Cambridge and Aberdeen.
4. Plant Breeding at Cambridge and Aberystwyth.
5. Fruit Growing at Long Ashton, Bristol, and East Malling, Kent.
6. Dairying at Reading.
7. Plant Physiology at the Imperial College of Science.
8. Agricultural Economics at Oxford.

The Plant Pathology Institute at Rothamsted represents a combination of previous Institutes, dealing separately with entomology, mycology and helminthology. Experience had shown that plant pathology must be treated as a single subject in which workers in these three directions co-operate, and must further be associated with workers upon the soil, because the incidence of the particular disease is in many cases determined by soil conditions. It was, therefore, decided to combine the staffs of the respective Institutions and to place them at Rothamsted, where they would be in daily contact with the workers upon soil and plant problems.

While the main Institute for the investigation of the nutrition of the animal is situated at Cambridge, the Research Department at Aberdeen is attacking different aspects of the same general problem, there being an understanding between the two bodies to prevent overlapping and to secure proper pooling of results. The Institute at Cambridge does also deal with other problems connected with the rearing of animals, such as those connected with the physiology of reproduction. Again, the Balfour Professor of Genetics at Cambridge receives a grant in order to carry out investigations into the laws of inheritance in animals which may prove of service in developing the science of breeding.

The Plant Breeding Institute at Cambridge deals chiefly with cereals and other farm crops, while the more recently founded Station at Aberystwyth is more specially concerned with grasses and clovers and oats and fodder crops appropriate to the wetter climate of the west.

In order to relieve the Institutes engaged in plant breeding of the work of commercial distribution another Institute, the National Institute of Agricultural Botany, has been set up at Cambridge, for the endowment of which Sir Robert Macalpine and Sons, together with members of the seed trade and others interested in agriculture raised

a fund of approximately £45,000. The main function of this Institute is to receive new varieties of farm crops from the Plant Breeding Institutes, grow them on and test them on a large scale before putting them on the market in commercial form.

The two Institutes dealing with fruit problems at Long Ashton and East Malling respectively, work in very close harmony, even in many respects with a common programme, adapted to the fact that they fairly represent the different conditions of soil and climate attaching to fruit growing in the eastern counties and the west country respectively.

A small Experiment Station at Waltham Cross, supported partly by contributions from the industry and partly by a grant from the Development Commission, deals with the problems of the fruit and vegetable grower who works under glass. This Experiment Station works under the general supervision of Rothamsted.

The workers on plant physiology at the Imperial College of Science are associated, for the purposes of obtaining material and for the conduct of the field experiments they need, with the Fruit Growing Station at Long Ashton, the Experiment Station at Waltham Cross, and the other Institutes like Rothamsted that are conveniently situated for the work in hand.

There is as yet no specific Institute dealing with research into the diseases of animals. The Ministry of Agriculture, however, supports a Research Laboratory at Addlestone, where certain questions specifically bearing upon the administrative work of the Ministry are investigated. A grant is also made to the Royal Veterinary College for research work. A further grant is being made to workers at the London School of Tropical Medicine for investigations into internal parasites of domestic animals.

This broadly outlines the Institutes now in being; of the actual work they have in hand some indication will be given later.

In addition to these grants to the Institutes, the Scheme provides for a fund, which at present stands at £3,000 a year, from which grants may be made to individuals in furtherance of approved schemes of investigation. This special research fund is intended for the benefit of teachers, etc. in agricultural colleges, Universities, etc., other than the Research Institutes, and from it an investigator can obtain that assistance for a particular piece of work which is beyond the normal resources of the institution to which it is attached. This fund is administered by a special committee of experts to whom the applications for grants are referred.

In order to ensure whatever co-ordination of effort may be necessary there has been set up a Research Council, consisting of the Directors of the various Institutes with a few independant scientific men and the officials of the Government Departments concerned. The chief business of this Council is to consider each year the programme submitted by each Director for his Institute. In this way expert criticism can be directed on any proposal and suggestion for co-operation and the avoidance of wasteful effort can be made. For reasons stated above it is in practice impossible to treat agricultural research as a single whole, nevertheless the Research Council does ensure a general review and some unity of purpose. Further, to it the Ministry is able to submit proposals for large scale investigations which may require the co-operation of a number of Institutes, or again of the Educational Institutes.

An essential feature of the Research Scheme has been the further provision of a number of Advisory Officers attached to the various agricultural colleges, and relieved in the main of teaching functions in order that they may give advice to the farmers and horticulturists in their area, and conduct local investigations for their benefit. Eventually it is hoped to provide each college with three officers, as a rule a mycologist, an entomologist and a chemist, varying, however, with the special needs of the locality. Regular conferences are held between these officers, more especially the pathologists, the Directors of the related Institutes, and the scientific officers on the Ministry's staff. In this way a systematic service is obtained to deal with plant pathology all over the country, from which may be secured a general review of the prevailing conditions and a combined attack upon any disease of widespread distribution. At the same time, the Advisory Officers serve as intermediaries between the Research Institutes and the farming public, on the one hand disseminating the results of practical moment, and on the other, advising the Institutes of problems that have been revealed locally which may

prove to be beyond the resources of the individual adviser.

The total funds set aside in the current estimates for this research service amount to £105,000, as compared with £38,250 for 1913-14, immediately before the War. The greater part of this expenditure goes upon salaries of the research workers and the Ministry, as the main source of funds for the various Institutes, has laid down for each Institute a definite establishment with incremental scales of salary attached to each grade. The State, in fact, subject to the usual Parliamentary limitations, undertakes for each Institute to provide the salaries with certain increments for a defined number of officers. But it does not thereby set up a State service or make the workers civil servants, because they receive their engagement from and are responsible to the Governing Body of each Institute. What the Scheme does ensure is that certain rates of pay and certain prospects of promotion shall lie before the individual who enters upon the career of agricultural research: otherwise that career is apt to become a blind alley employment, attractive perhaps for some years to a keen scientific worker, but possessing the poorest of prospects unless he can make himself of industrial value. It is no good entrusting so complex and difficult a matter as investigation of an agricultural character to any but the best minds, and the scale of salaries that has been drawn up in connection with the scheme is the least which can be considered likely to tempt highly trained men from the Universities into this somewhat narrow and highly specialised profession. Of course, research of the highest kind, real discovery, depending as it does essentially upon imagintion, cannot be secured by any salary system, any more than poetry can be thus bought, but what one can hope to do is to give a certain number of men a trial and then ensure that the right man, who sooner or later arrives, will have fitting conditions for his work. A system of scholarships enables promising young men, after they take their degrees, to engage in research under the guidance of one or other of the Institutes, from which scholarships they can succeed to an assistantship on probation. Even if the man, after four or five years, proves unfitted for a permanent career of investigation, the training in research will have been his best possible introduction to the profession of teaching or expert work in connection with agriculture.

In the scheme thus outlined it is recognised that there are still certain gaps to be filled. The future development of large scale agriculture essentially depends upon the application of machinery to farm work, and existing machinery probably requires certain radical modifications in view of the greater pace at which implements can now move because of the general introduction of mechanical power upon the land. Certain proposals in this direction have been under consideration between the Ministry, the Development Commission and the Department of Research, but the present embargo on new expenditure must postpone any progress for a time. Moreover, for research of this description the co-operation of the great implement manufacturing firms must be assured.

Again, the immensely important subject of animal disease is now very inadequately dealt with. It is necessary to attack it from a broad standpoint, in connection with human medicine, both as regards the extension to animals of the methods of dealing with disease in man and again as regards the many parasitic diseases that run a double course in both man and the domestic animals. It may be desirable to set up an institute for research into the comparative pathology of men and animals, or the work may be better promoted by setting up a directing committee on the lines of the Medical Research Committee, but the work is needed and can look to results of vast economic importance, both to the livestock industry of the country and to public health. A special committee of the Development Commission has been set up to review the situation. Lastly, the Institute dealing with Animal Nutrition at Cambridge only deals with a portion of the great subject of Animal Husbandry which embraces the breeding, rearing and feeding of animals economically. While it may be recognised that the breeding of animals is a much more complex question than the breeding of plants, and that the inheritance of such characters as rate of growth, milk yield, egg laying capacity, yield and quality of wool, is far more intricate than that of plant characters, and is, moreover, governed by other considerations, *e.g.*, of a physiological character, enough has been learned to show that Mendelian principles may be applied to

their investigation with some prospect of ultimate success. Again, the raiser of live stock is confronted with a number of physiological problems connected with the reproduction process, and again there is a great field of investigation of an economic character on such practical questions as early maturity, in which the alternative methods practised by experienced breeders and graziers can be accurately studied. What is needed is the expansion of the Cambridge Institute into a wider scheme dealing with Animal Husbandry as a whole. The men capable of doing the work are there but as it deals with live stock and as it must be carried out on a large scale in order to eliminate the individuality of the animals under experiment, considerable expenditure is necessary, beyond the resources of the present Institute. In this respect an appeal for funds must be made to the live stock industry. The State now contributes about £10,000 a year for research at the Cambridge Institute alone and has reached the limit it can provide. It remains for the farmers and breeders of the country to show their sense of the importance of the work that is being carried out for their benefit by taking upon themselves a share in the expense. Considering that the annual output of livestock and animal products in the United Kingdom is estimated to be worth about £350,000,000 annually, it should not be impossible for the producers to contribute another £10,000 a year for the purpose.

Having thus dealt with the organisation of research, it may not be out of place to indicate a few of the most important practical results which have accrued from the work of the various Institutes.

At Rothamsted a very valuable investigation has recently been carried out on the bacterial processes which bring about the making of farmyard manure, a subject which has occupied the attention of investigators for many years, but which now seems pretty definitely cleared up. The basis of the work was the discovery by Hutchinson of a cellulose fermenting organism which brings about the humification of the straw. This widely distributed dimorphic organism—a Spirochaete—is strongly aerobic, but does not attack straw unless at the same time some active form of nitrogen is supplied. Wet straw alone will not rot down. The active nitrogen which is supplied by the urine from the stock is necessary to start up the process, and there is a certain definite relation between the weight of the straw and the amount of nitrogen which is absorbed for the humification process. This first change, is in practice always accompanied, as other observers have shown, by a certain loss of nitrogen—10% to 15% under the best conditions. Afterwards there follows a second an-aerobic change, during which methane and hydrogen are given off and the mass tends to arrive at a material of very constant composition as far as regards the proportion of nitrogen to dry matter. This constantive composition in the finished rotted dung may be attained by the evolution of nitrogen gas on the one hand or by its fixation through the appropriate organisms on the other. One of the most interesting results that have been observed is that bacterial action in the opposite sense—the fixation and the destruction of nitrogen compounds, the formation and destruction of nitrates—may be going on simultaneously in different parts of the same dung heap. The chief practical lessons that emerge are that rich cake-fed dung must be got early on the land before it is made if great losses of nitrogen are to be avoided. Also that the most essential feature in the treatment of the ordinary dung heap lies in protection from washing by rain.

Some of the principles brought to light in the course of this investigation have been applied with remarkable success to the treatment of sewage. Current processes of handling sewage cannot recover its most valuable constituent, the soluble nitrogen compounds, which are either fermented to destruction or escape in the effluent and cause trouble in the streams. If, however, the crude sewage be passed through a filter bed made up of straw, the straw will pick the soluble nitrogen compounds out of the sewage in order to start the humification process. Some 60 per cent. of the nitrogen is removed from the effluent which becomes comparatively harmless, and the straw itself is converted into manure. At Wainfleet this method has been applied with most promising results to deal with the sewage from a camp of some 200 men.

Further trials are in progress to work out a method of making farmyard manure on a large scale without animals. If successful this method would be of great commercial utility to market gardeners,

who now find their business imperilled by the immense diminution that has taken place in the supply of town stable manure.

No other line of research has given such valuable results as the scientific breeding of farm crops along scientific lines. Biffen at Cambridge has produced wheats which under East Anglian conditions add ten per cent. to the yield of the farm. Some of these wheats also combine the "strength" of Canadian wheats with the cropping powers of English. Other cereals in process of working up may go far to solve the problem of lodging, which has become the chief practical limitation to the increase of yield in the United Kingdom. Again, spring wheats and wheats suitable for more northern climates are being raised. Other farm crops are equally susceptible of improvement; particularly it is necessary to set to work on root and fodder crops, taking as criterion not merely the weight of crop or its appearance, but the amount of food produced per acre. All selection in the future, whether of plants or animals, must accept the utility standard. At the second plant breeding station at Aberystwyth work was being chiefly directed to the grasses and clovers. Examination of individual grass plants shows wide variation in their leafiness and tendency to form seed. The more leafy a grass, the more valuable is it in a pasture, yet the tendency must always have been to save seed from those individuals which ran up most early and completely to seed. Seed is now being saved from fields constituted originally by the division of grasses with a leafy habit.

In connection with plant nutrition, what the station at Cambridge is obtaining is a set of real growth curves showing for each stage of the animal's development the relation between the food consumed, the live and dead weight, the useful meat and fat and the offal. Such curves do not as yet exist, and the fattening process is probably in consequence often pushed to a wasteful point; with more knowledge we can produce meat in the most economic fashion. At Aberdeen, investigations into the vitamine factor in the nutrition of farm stock is leading to valuable results; both with poultry and pigs many troubles of malnutrition arise in practice through the neglect of these food accessories.

The research in fruit growing has at the outset shown that the stocks upon which apple and other fruit trees are worked are hopelessly mixed instead of being uniform, with the consequence that the orchard planted upon these stocks will also lack uniformity in habit, cropping power, disease resistance, etc. The confusion had been cleared up as regards apples, and it was now possible to begin with true stocks best suited to the conditions of the orchard. Research is also in progress on fruit preservation. One of the greatest difficulties of the fruit grower is the occurrence every few years of a glut, especially among soft fruits, when what ought to be a bounty of nature, benefits the consumer but little, and makes the grower's business unprofitable, because the channels conveying the perishable fruit to the public cannot suddenly be enlarged. Some rapid and cheap process is being sought, whereby the fruit could be put into store for future use by the jam-maker and the consuming public.

As regards disease, what is being generally sought for is immunity rather than curative methods, as witness the success that had attended the production of varieties of potatoes immune to wart disease, a disease which had so far defied all attempts to eradicate it from the soil in which it had once obtained a foothold. Yet the immune varieties of potatoes will grow without a blemish in the most heavily infected soils.

Economic investigations must lie at the base of all considerations of farming processes. The Research Institute at Oxford deals with this question, and has begun by working out methods for ascertaining the cost of production of agricultural produce. In addition to the development among farmers of accounting by education, any agricultural research when it reached the practical stage of application to farm practice must have its economic investigations also, and it is one of the functions of the Oxford Institute to show how such enquiries can be made.

This lecture has chiefly been concerned with organisation and the machinery of research, but as I have said before, in this matter of research it is above all the man that counts, and I do want to take this opportunity of declaring with all the emphasis of which I am capable, that we have got the men and that the State is getting value for its expenditure. Our organisation for agricultural research is young, neither in the numbers of workers engaged nor in the expenditure can we compare

with America or with Germany before the war, but I fear no comparison in considering the results that have been attained during the last twenty years or so. It is not too much to claim that the majority of really fruitful ideas and conceptions that have recently become current in agricultural science have sprung from English laboratories. Rothamsted is at present undoubtedly the most completely and efficiently equipped agricultural laboratory in the world, and while the other Institutes are on the material side not so well found as yet as Rothamsted, they all display an activity of mind and a fertility of invention and method that can be matched in no other country. Our scheme is still incomplete, our workers are handicapped by insufficient resources, but do not let us extend our English habit of self-depreciation to their outstanding quality and immediate achievement.

EXPENDITURE ON AGRICULTURAL RESEARCH.

The expenditure by the Ministry of Agriculture and Fisheries on Agricultural Research in respect of work carried out during the academic year ended 30th September, 1920, was approximately as follows:—

Grants to Colleges and Institutions in aid of	
(*a*) Scientific Research and Experiment	£
(i.) Capital Expenditure (statement A)*	28,588
(ii.) Maintenance Expenditure (statement B) ..	52,470
(*b*) The Extension of Advisory and Local Investigation Work (statement C) ..	13,798
(*c*) Special Investigations and Researches not included above (statement D) ..	2,028
Experiments with Agricultural Machinery*	4,000
Miscellaneous Enquiries, Experiments, etc.*	1,500
Research Scholarships*	1,900
	£104,284

* Financial Year ended 31st March 1921, estimated.

STATEMENT A.

CAPITAL GRANTS.

Amount PAID in Financial Year, 1920-1.

(N.B. In the past these have not usually appeared on the Ministry's Vote and have been made direct from the Development Fund.)

Institute.	Subject of Research	Work.	Amount.
			£
East Malling Research Station	Fruit Growing ..	Building and Equipment ..	1,173
Rothamsted Experimental Station	Plant Pathology ..	Buildings ..	2,065
Welsh Plant Breeding Institute	Plant Breeding ..	Buildings, Laboratory, Greenhouse, Farm	6,100
University College, Reading	Dairying	Farm and Buildings ..	14,000
Bristol University	Fruit Growing ..	Farm	5,250
			£28,588

STATEMENT B.

Maintenance Grants.

Institute.	Subject of Research.	Amount Paid in respect of Academic Year 1919-20. £
Birmingham University	Helminthology	1,116
Bristol ,,	Fruit Growing	6,500 (a)
Cambridge ,,	Animal Nutrition	7,691
,, ,,	Plant Breeding	3,977
,, ,,	Small Animal Breeding	935 (a)
Imperial College of Science	Plant Physiology	2,943
Oxford University	Agricultural Economics	3,391
Reading University College	Dairying	4,800 (a)
Rothamsted Experimental Station	Plant Nutrition and Soil Problems	9,781
,, ,, ,,	Plant Pathology	4,023
Royal Veterinary College	Animal Pathology	1,314
South Eastern Agricultural College, Wye	Fruit Growing	2,250
Waltham Cross Experimental Station	Glasshouse Culture	1,000
Woburn Farm	Fruit Growing	1,073
University College, Aberystwyth	Plant Breeding	775 (a)
Oxford University	Bees	635 (b)
Cambridge ,,	,,	266 (b)
		£52,470

(a) Approximate. (b) Financial year 1920-1.

STATEMENT C.

Provision of Technical Advice and Investigation of Local Problems.

Institute.	Amount paid in respect of Academic Year 1919-20. £	Institute.	Amount paid in respect of Academic Year 1919-20. £
Aberystwyth University College	1,490	Reading University College	590
Armstrong College	1,486	Wye, South Eastern Agricultural College	2,200
Bristol University	1,540	Manchester University	743
Bangor University College	1,805	Harper Adams Agricultural College	300
Cambridge University	1,608		
Leeds University	1,500 (approx.)		
Midland Agricultural and Dairy College	536		£13,798

STATEMENT D.

Special Investigations.

Institute.	Research.	Amount paid in respect of Academic Year 1919-20. £
Cambridge University	Itch Mites of Domestic Animals	157
,, ,,	Feeding Value of Oat and Tare Silago	230
Oxford University	Soil Survey	500 (provisl.)
,, ,,	Rural Industries	128
Royal Horticultural Society	Green Manuring	200
London School of Tropical Medicine	Helminthology	240
Rothamsted Experimental Station	Sewage Sludge	375
Aberystwyth University College	Botanical Survey	103
East Anglian Institute of Agriculture	Soil Solution	18
Imperial College of Science	Gall Weevil	77
		£2,028

DISCUSSION.

The Chairman (Lord Bledisloe), in opening the discussion, said he was sure everyone present was very grateful to the Lecturer for his most illuminating and very optimistic address. There was no doubt, making due allowance for the enthusiasm of outside workers, that Sir Daniel Hall's scheme for the distribution of research work according to subjects over several different Institutions, with a Research Council to act as a clearing house and to co-ordinate their activities, had already given, and would continue to give, an immense impetus to agricultural research in this country, and was calculated to have very far-reaching results. The detachment of those research workers from direct Government interference was, in his judgment, most salutary. As an old and rather active politician, he was bitterly conscious that Government policy in such matters was apt to be hectic and vacillating, swayed by possibly ignorant pressure from some temporarily dominant political faction. The work of the scientific investigator was best conducted in a more tranquil atmosphere, inspired solely by the enthusiasm of a creative imagination backed by carefully ascertained knowledge, and, above all, prompted by the laudable ambition to leave the world enriched by his life's activities. For the same reason it was most essential that the work of research investigators should not be disturbed by domestic disquietude consequent upon insufficient financial remuneration. It had come to his notice during the recent months, when the cost of living had been so high, that many of the most eminent research workers had found it extremely difficult to make two ends meet and had thereby been distracted from the important work they had undertaken. In his judgment, no part of the scheme which the Lecturer had sketched out was more important or more fruitful in results than the provision of advisory officers connected with the various Colleges and educational Institutions, as a means of liaison between the research workers on the one hand, and the practical farmers and gardeners on the other. He was interested to note that in the lecture it was stated: "If agricultural research is to remain alive, it must continuously be kept in contact with the business of farming," and he thought everyone would agree with the importance of that statement. The Lecturer had pointed out two rather curious gaps in the present scheme of research, one of which was connected with animal disease. With regard to that, it was interesting to remember that the creation of the Department of Agriculture in this country came about owing to the necessity for dealing with the contagious diseases of animals, and yet, curiously enough, effective research work to elucidate that subject had not yet been set up, with the result that in the case of a disease, such as foot and mouth disease, which had, unfortunately, been so prevalent recently, very little more was known about it than was known some fifty years ago. Sir Daniel also referred to machinery, and it seemed to him that struck a somewhat different note from almost everything else in the lecture; it sounded somewhat dead and inert compared with all the other subjects of proposed systematic investigation, except possibly that of agricultural economics. Machinery was, however, very nearly related to much of the most valuable work being conducted at Rothamsted and elsewhere. He could himself just remember the time when the craze for deep cultivation, which he ventured to hope would not be over emphasised at the present time, resulted on the ferruginous soils of West Gloucestershire, where he lived, in not merely burying out of reach of plant nutrition the valuable humus and bacteria to be found in the top six inches of soil, but leaving on the surface poisonous ferrous compounds which had done actual damage to plant growth. He hoped that when machinery research was developed precautions would be taken against a similar unfortunate experience. In his judgment, the most fascinating part of the lecture, *i.e.*, that which dealt with the recent output of what he might call the research factories, was all too short. It was curious to observe how far investigators were as yet from complete knowledge as to the chemical and bacterial processes going on in farmyard manure, the most ancient and, probably still, the most valuable of all land fertilisers. He remembered that when he was studying law at Oxford he learned from those interesting and ancient jurists, Gaius and Justinian, in their description of early land tenures and legal usufructs in the Roman Empire, the great manurial value which was then ascribed to animal dung. As Dr. Russell had repeatedly pointed out, before the time of Liebig in 1840, farmyard manure was deemed essential for all crop production without any sort of recognition of the value of alternative applications of a chemical character, and yet Sir Daniel Hall was now pointing out that the time had arrived when by some synthetic process a new "farm yard manure" might be artificially fabricated and the animal dispensed with altogether. Only the previous week he saw in the papers that some other expert was telling the country that milk of a non-tuberculous character would be similarly produced by some synthetic process. In conclusion, he wished to say, as Chairman of the committee of the Lawes Agricultural Trust, how very much he appreciated the hansdome tribute which the Lecturer had paid to the Rothamsted Experimental Station, which was the oldest and still the greatest agricultural experimental station in the country. He felt bound to express some regret, with which he thought Dr. Voelcker would sympathise, that the very valuable work which had been conducted at Woburn for so

many years by Dr. Voelcker and his father, under the ægis of the Royal Agricultural Society, seemed likely to be abandoned in the future. Personally, he held very strongly the view that the great agricultural societies were more likely to justify themselves in days to come in the public eye by showing definite and generous sympathy with agricultural research than merely by holding exhibitions of live-stock, useful though these undoubtedly were.

DR. E. J. RUSSELL, D.Sc., F.R.S. (Director of the Rothamsted Experimental Station) said he had listened to Sir Daniel's admirable lecture with very great interest. Sir Daniel apologised for dealing at such length with organisation, but after all, organisation was the basis of the work, and it was quite certain that if there had not been good organisation it would not have been possible to retain the men who were at present in the agricultural service. After the Armistice, most of the Research Institutes were in danger of losing their best men because they were being tempted away by industrial concerns. No research station could be run successfully on the principle of the survival of the unfit; the best men must be retained. Speaking as the Director of an experimental station, he could say that the present organisation was good, and he hoped that whatever alterations or re-arrangements might be made in the future, the essential features would remain as they were at present. One of the essential features was the recognition that research was an individual effort, and that the output of research work of any body of men depended entirely upon themselves, and could not be increased by co-ordinating Committees outside, although such Committees might help by bringing facts or problems to the notice of the research workers. That threw on the Research Institute itself the responsibility for turning out good work, and that responsibility was rather a serious one, because it was extraordinarily difficult to judge at the time the work was being done whether it was going to be helpful in the future. The value of a piece of work lay not so much in the research itself, as in what it stimulated other people to do; it might suggest ideas, and so lead to some great result, which was not anticipated at the beginning. The investigation into the decomposition of farm-yard manure could be traced back to a very simple experiment started in 1882 by Lawes and Gilbert, which had nothing whatever to do with farmyard manure. In the year 1882, the weather at harvest time was so bad that the whole of the crops could not be got in, so Lawes and Gilbert fenced off a piece of the ground and left it to run wild. For some years it did not seem as if there would be any practical result from that, but certain changes going on led Sir Daniel Hall to examine it, and to show that there was some nitrogen fixation; that led Dr. Hutchinson to study some of the processes, and that led to the deduction that the decomposition of cellulose was brought about by the aid of nitrogen, which in turn, led to the study of the mechanism of the decomposition of cellulose. That was linked on to another investigation, *i.e.*, the changes going on in the production of farmyard manure, and it was by connecting up those different lines of investigation that the results were obtained to which the Lecturer had alluded. There were two general ways in which such investigations could be carried out. Occasionally it would happen that someone would see the whole problem and the solution in a flash, and the whole thing was done almost at once. Much more frequently, however, progress was slow—painfully slow sometimes—and had to be done by means of team work. One had to get three or four people interested in it, and that was where the chief problems of Agricultural Institutes lay now-a-days—to secure close co-operation between men who were looking at the subject from wholly different points of view. Whilst an investigation should never be turned down because it seemed unlikely to have any practical results, he did not think the Director of a Research Institute could take the responsibility of running the Institute entirely regardless of results. It would, of course, be fatal to go in solely for those researches which seemed to promise a practical result, but at the same time it must be remembered that there was a responsibility to the community, which, in return for its sums of money, was entitled to have something that was not pure academic knowledge. That was where the great advantage of the present organisation came in. It was left to the Institute itself to decide what programme of work it should follow, what researches it should develop, and how it should develop them. The two chief problems that were now troubling the Institutes were the following. They were not completely satisfied yet that they had made as many bridges as were desirable between the research station and the farm, and were seeking for some machinery whereby the research workers could be kept in close touch with farm problems without at the same time having to break continuity with their laboratory investigations. They wanted to devise a system whereby, if possible, the farmer would know what the research worker was doing, and certainly the research worker would know what the farmer was doing. The second problem was with regard to the publication of results. Results had to be published for two reasons, the first being to obtain the criticism of other workers. It was a very great advantage to have a scientific journal where results could be published and criticism obtained. At the present moment such scientific journals were having the greatest difficulty in paying their way; some had a circulation of only three or four hundred, and were having to reduce their number of pages. Unless some

remedy was found for that, a very serious problem would arise, as he was afraid that there would be great difficulty in having the results adequately criticised by scientific workers who were capable of criticising them. The other reason for the publication of results was that they might be disseminated amongst the farmers. In his experience there was no difficulty whatever in getting papers accepted which dealt with some practical subject: the difficulty was to find people to write them. Very often the research worker himself could not do it; his interest was in the problem, and when it was solved he went on to something else, so that the writing up of the subject had to be done by somebody who had not actually carried out the work and had not first-hand knowledge of it. That difficulty might be overcome in time. In this country there were one or two men like Sir Daniel Hall, who had first-hand knowledge of such matters, and were able to get at the farmer. He wished to congratulate the Royal Society of Arts on having persuaded Sir Daniel to deliver the present lecture. If such lectures could be given at meetings of the Farmers' Union up and down the country, showing the farmers that scientific work was a useful thing for them, he did not think there would be much difficulty in obtaining the £10,000 that Sir Daniel wanted, and the further thousands of pounds that Rothamsted was going to ask for, as soon as a propitious opportunity presented itself.

Mr. H. W. Thomas, speaking as a farmer, said he had been very much interested in the lecture, especially that part of it which dealt with the composition of farmyard manure. He gathered from what the lecturer had said that the value of the food used in making the manure did not matter much, and that, whether a large amount of cake and corn was given to the animals or not, when the manure was finally decomposed, it contained about the same amount of nitrogen.

Sir Daniel Hall replied that the way the animals were fed made a great deal of difference, if the manure was put on the land quickly, in the green state. It was only when the manure was allowed to become decomposed and rotted down to its final state that further nitrogen was lost.

Mr. Thomas, continuing, said he happened to have some sewage running through his farm. Sometimes it was run into a tank and treated by settlement, and sometimes it was run direct on to the land. He took it that he would be well advised if he had straw to spare, to put it into the tank and allow the sewage to run through it and rot it.

Sir Daniel Hall replied that the sewage must be trickling over the straw so that there was plenty of air at the same time. He could give Mr. Thomas particulars of how the installation referred to in the lecture had been worked.

Mr. Edward Packard said one of the greatest difficulties in agriculture was to get the knowledge of scientific men communicated to the people. Some 45 years ago he read a paper before the Farmers' Club, advocating the establishment of scientific agricultural stations throughout the country, and the late Mr. Albert Pell asked who was to do it, and answered his own question by saying that the landlords must do it. In some cases, landlords had done it. There was one such case in Bedfordshire and another in Northumberland, and quite recently a large land owner in Suffolk had purchased a property upon which he was going to establish some sort of agricultural college or institute. That, however, was not sufficient, and what was really wanted was greater support from the State to enable agricultural institutes to go ahead and carry out their work without having to think of the expense. The State should also provide sufficient money to enable the agricultural institutes to publish the results of their work. The lecturer had stated that something like £100,000 a year was given by the State to help agriculture in a scientific way, but £1,000,000 a year, or at any rate, £500,000 was required. It would not be wasteful expenditure, because it would be profitable not only to the farmer but to the country as a whole, if the results of scientific research were published.

Sir Thomas Middleton, K.B.E., C.B., said no part of the Lecture appealed to him more than the concluding sentences, in which Sir Daniel paid a tribute to the men working in the Research Institutes. Personally he was perhaps in a better position than anyone else to realise how much the country owed to those men. Sir Daniel was now in the fortunate position of being able to help them, whereas, during much of the time when he himself was a member of the Ministry, there were no funds available to assist the scientific workers. In spite of that, an immense amount of valuable work was done by men attached to the Colleges —by Dr. Russell at Wye, by Prof. Biffen at Cambridge, and by many others. Their work was done for the sake of research, and they got no remuneration, the time devoted to it being the time they could spare from teaching duties. The success which had followed the expenditure of the Development Fund was very largely due to the preliminary work carried out by the younger scientific men in the Agricultural Colleges during the first ten or twelve years of the present century. There was a great deal more still to be done, and he was glad to hear the Lecturer point out that it was not only to the Development Commission that people must look for funds in the future. The industry must do something for itself. The Lecturer had indicated one subject,

in which the need was clamant, and he hoped Sir Daniel would see that the live stock industry put down something substantial for the development of the work at Cambridge.

DR. J. A. VOELCKER said the Society was celebrating on the present occasion the work of Sir Henry Trueman Wood, and it must not be forgotten that agriculture was one of the many subjects in which Sir Henry took an interest, and to which he gave his assistance. He, therefore, thought the Society had been happy in the choice of the lecture and of the lecturer. Sir Daniel had shown that he had research at heart, and was not going to be too much tied by Departmental methods. The record of his activities—his high scientific training at the outset, his work at Wye College, his splendid direction of the Rothamsted Experimental Station, and then his organisation of agricultural research through the Development Commission—showed the cause of the success that had so far been achieved and which led one to look hopefully to the future. The lines upon which agricultural research had been organised in this country were, he believed, the right ones. His own experience had amply shown him the defects of isolation. Frequently when he had had investigations to pursue, he had felt the need of a worker on some other branch of the subject. He might even say that, if he had had the advanrage of working alongside others and had had the support of such a scheme as that which the Lecturer had described, the giving up of the Woburn Experimental Station, to which reference had been made, might not have had to be contemplated. He thought that in the drawing up of the scheme for the organisation of research, the Lecturer and those who had worked with him had shown a proper appreciation of how far control should go, and of how far wider views and consideration for individual workers should carry weight. Although personally he had the misfortune to stand more or less alone, he had to thank the scheme of research put forward by the Development Commission, and Sir Daniel in particular, for the support that had been given to him. Accordingly, the scheme had the advantage not only of bringing in the different Colleges and Institutions, but also of looking after the individual worker. He thought the Lecturer had shown that there was an immense amount of work still to be done. Live-stock alone demanded great attention, and if those who, as in the case of the Royal Agricultural Society, had given up chemical research in favour of live-stock, would contribute some of the £10,000 a year that was required, he thought they would be showing the right spirit.

LIEUT.-COLONEL G. L. COURTHOPE, M.P., in moving a vote of thanks to Sir Daniel Hall for his lecture, said he agreed with Dr. Russell that it would be extremely useful if Sir Daniel could read such a lecture at meetings of the National Farmer's Union up and down the country, but he thought it would be infinitely more valuable if Sir Daniel could read the present lecture about every other year in the House of Commons. Although it was quite right that the agricultural industry should be expected to contribute on a handsome scale to the maintenance of research and the Institutes that made research possible, it must be remembered that Parliament held the strings of the public purse. Nearly everyone who had spoken in the discussion had referred to synthetic farmyard manure, which was a fascinating subject, and opened up an immense vista of possibilities. He hoped the appalling waste which went on at the present time in the disposal of the sewage of the country might be gradually dealt with on some such lines as were suggested in the Lecture.

MR. JAMES FALCONER, M.B.E., in seconding the motion, said he had been greatly interested in the Lecture, and especially in what he might call the more practical part of it. With regard to farmyard manure, he thought it was a shame that so much valuable manure was wasted in the cattle yards of England. In the best feeding districts of Scotland at the present day there were hardly any open yards. They had a system of feeding cattle inside, and put in large quantities of straw; no farmer in that part of the world would ever think of selling a ton of straw. When he was a young man, farming in Scotland on a small scale, there was a great controversy about the use of farmyard manure, and it was then said to be proved that if the manure was carted away in a green state and spread on the land at once, there was very little loss either by snow or by rain, but it must be ploughed in as quickly as possible. That was being done to-day in all the best districts of Scotland. He quite agreed with what the Lecturer had said about machinery. Ever since he came to England he had advocated the use of machinery, and a great deal of any success he had achieved had been due to the use of up-to-date labour-saving appliances. He also agreed with the Lecturer's remarks about Prof. Biffen's wheat. Personally he had found the best yielding wheat was little joss, combined with some of Prof. Biffen's wheats, which were doing very well indeed.

The motion was carried unanimously and the meeting then terminated.

"FISH SCALING" IN ENAMELS FOR SHEET STEEL.

Among the investigations being conducted by the United States Bureau of Standards is one designed to eliminate "fish scaling" (the jumping off of small particles) in enamels

for sheet steel. A recent report says that this "fish scaling" is probably the most serious defect to which enamels for sheet steel are subjected. It occurs intermittently in practically all the plants manufacturing this class of material in the United States, and entails losses running into millions of dollars to the manufacturers. The investigation was begun in July, 1919, and up to the present time the Bureau has made 90 melts of enamel comprised of 21 different compositions. These have been subjected to various treatments in firing and melting and have been applied in various ways to several kinds of steel. In all, over 4,000 sample enamelled plates have been made. This work has demonstrated that one of the most important factors in the production of fish scaling is too severe heat treatment in the firing of the enamel. Excess heat treatment may consist of firing the enamel at too high a temperature or of holding the enamel in the furnace for too long a time at a given temperature. Other important factors are the composition of the enamel, the physical and chemical characteristics of the underlying metal, the method of melting the chemical mixtures used in making the enamels, and the shape and weight of the metal pieces that are enamelled. These various factors have been investigated to a certain extent in this work and will be studied more thoroughly as the investigation progresses.

The data obtained in this investigation up to the present time have enabled the Bureau to be of very material assistance to several manufacturers in eliminating this trouble. It seems very probable that the completion of the investigation as now planned will definitely eliminate fish scaling, and likewise settle the interesting question of what is the physical basis of the phenomenon.

HAND EMBROIDERY INDUSTRY AT MALLORCA.

The value of the hand-embroidered articles produced in Mallorca during 1919 amounted to about 2,000,000 pesetas, or roughly £80,000. In the year preceding, the value was somewhat less than one-half the sum for 1919, due to conditions brought about by the War, and the temporary closing of important markets. The industry, happily for the island, is now again in a flourishing condition, and is rapidly recovering all its former markets.

The Spanish markets consume a little less than half of the embroidery output of Mallorca, purchases by Spain last year having totalled a trifle less than a million pesetas. The remainder went to the following countries, in order of amounts purchased: France, England, Argentina, other South American countries, and the United States.

Spain buys mostly the commoner, or less elaborate and consequently lower-priced embroideries, whereas France imports the really fine art work, in the production of which the island of Mallorca stands alone. However, much of the embroidery exported to France is re-exported to other countries as French lingerie, table linen, bed linen, etc., with no mention of Mallorca.

According to a report by the U.S. Consul at Palma de Mallorca, the French interests engaged in the local embroidery industry produce their own designs, forward their own materials already stamped for the embroidering, and after completion by the local needlewomen, the pieces are reshipped to France, usually to Paris, for cleaning, mounting, and finishing, the unique French style being thus assured to the finished article, a result unattainable with the use of local designs (more or less conventional), and materials, lacking as they too often do the fine textures of materials obtainable in the more important textile centres.

Until the outbreak of the late war, Germany was a very important consumer of Mallorean embroideries, and by means of its customs policy was enabled to import into Germany the embroideries produced in the island, to finish the same after the fashion of the French, and to re-export the completed articles to foreign countries under conditions enabling the German interests involved to compete successfully with the embroideries of any nation in the world. The plan followed was, in general, as follows: The German Government allowed embroideries to be imported into Germany, duty free, provided the pieces were worked upon cloth of German manufacture. Accordingly, such cloth was shipped to Mallorca, after having been stamped for purposes of future identification by the German customs at the port of export, sometimes carrying the design to be wrought thereon, and sometimes unmarked. Upon completion of the handwork in Mallorca, at comparatively little cost—the most expert needlewomen at that time receiving only about two or three pesetas (peseta=about 10d.) per day—the pieces were shipped to Germany, duty free, for final treatment.

The number of needlewomen engaged in the production of fine hand embroidery in Mallorca is estimated at approximately 3,500; of these about one in five is capable of the very finest work—work commanding very substantial prices because necessitating months of continuous labour. The classes of embroidery done are women's lingerie, in general: table linen, such as tablecloths, napkins, tea and luncheon sets; bed linen (sheets, pillow slips, and counterpanes); and towels.

The excellence of the Mallorean embroidery is not as widely known as it deserves to be, for the reasons above stated. In comparison with the product of other centres of the industry, it is said to be uniformly superior as to artistry, regularity, and general all-round "finish."

THE NITRATE INDUSTRY OF CHILE.

The following particulars regarding the nitrate industry of Chile are from data collected by the Latin American Division of the U.S. Bureau of Foreign and Domestic Commerce :—

Chile is the only country in the world known to contain commercially important deposits of nitrate of soda, a product which has a wide variety of uses, but is best known as a fertilizer. Two grades of nitrate are produced : 95 per cent., or ordinary nitrate, which is used for fertilizing purposes, and 96 per cent., or refined nitrate, which is used for manufacturing purposes. Before the War, approximately 75 per cent. of nitrate marketed was of the lower grade. Private business in Chile and Government revenue are both dependent on the prosperity of the nitrate industry, since this one product ordinarily constitutes nearly 80 per cent. of the country's exports, and the export tax on nitrate and its principal by-product, iodine, constitutes more than half the Government's total income.

The nitrate fields, the principal source of Chile's wealth, are limited to a narrow strip of arid desert located on the eastern slope of the coastal range, west of the cordillera of the Andes, at an altitude of from 2,000 to 5,000 feet above sea-level, and inland a distance varying from 16 miles in the northern part of the zone to 90 miles in the southern part. This region extends south from the valley of the Camarones River, the northern boundary of the Province of Tarapaca, to the southern boundary of the Province of Antofagasta. Outside of this area there are only the negligible deposits in the Province of Tacna, and a few isolated deposits the exploitation of which on a commercial scale is practicable in the Province of Atacama.

There is a great deal of speculation concerning the probable duration of the beds, but the very range of the conclusions arrived at shows on what inadequate data they have been based. One expert estimates the explored deposits to contain 240,000,000 metric tons of nitrate, and calculates the contents of the unexplored region to be twice as large. According to these figures it would require over 240 years to exhaust the supply at the present rate of production. Other estimates are less optimistic and set a much earlier date for the exhaustion of the beds.

The nitrate region consists of five important districts, namely, Tarapaca, Tocopilla, Antofagasta, Aguas Blancas, and Taltal, and a few smaller deposits, somewhat detached from these main fields, such as El Boquete, Pan de Azucar, Providencia, and Pampa San Juan. The relative importance of the principal districts is shown by the following table, giving the number of oficinas producing plants operated in each district, the extraction of caliche (the raw product from which nitrate is produced), and the amount of nitrate derived, during 1917 :

Districts.	Oficinas in operation.	Caliche mined.	Nitrate produced.
		Metric tons.	Metric tons.
Tarapaca	76	10,330,984	1,302,921
Tocopilla	7	1,822,334	227,900
Antofagasta ...	30	9,172,026	1,076,568
Aguas Blancas	7	1,066,473	145,590
Taltal	9	1,923,257	248,053
Total ...	129	24,315,074	3,001,032

Each of these zones is an independent unit with its own ports and railways. The Tarapaca district has four ports, Iquique, Pisagua, Caleta Buena, and Junin, and these ports are connected with the nitrate fields by the Nitrate Railways Co., the Agua Santa Nitrate and Railway Co., and the Junin Nitrate Railway Co. The Tocopilla district has one outlet, the port of Tocopilla, which is connected with the interior by the Anglo-Chilean Nitrate and Railway Co. The Antofagasta district has two ports, Antofagasta and Mejillones, and is served by the Antofagasta and Bolivia Railway. The Aguas Blancas district is served by the port of Caleta Coloso and the Antofagasta and Bolivia Railway. The district of Taltal has only one port and one railway, both bearing the name of the district.

Caliche differs in appearance and composition in various zones, according to a report presented to the American Institute of Mining Engineers. It usually contains (besides sodium nitrate) sodium chloride, sodium sulphate, potassium nitrate, sulphates of lime and magnesia, sodium iodate, and sodium biborate in varying proportions. The sodium nitrate content varies from less than 10 per cent. to over 70 per cent., the average sodium nitrate content of the caliche extracted during 1917 being 17.48 per cent.

The mining of caliche is very simple. A small shaft is sunk through the surface strata and through the caliche layer ; a charge of powder or dynamite is inserted and exploded ; and the lumps of caliche are sorted by hand from the resulting débris and loaded on carts. These carts carry about two tons and are drawn by from three to six mules. If the distance to the refining plant is short, the caliche is delivered direct, otherwise it is reloaded on light freight cars for shipment.

Arrived at the oficina or maquina, as the refining plant is sometimes called, the caliche is first crushed and then boiled in a huge tank of water. This boiling dissolves the nitrate and other salts and leaves the sand and similar refuse on the bottom of the tank. The dissolving process completed, the nitrate solution is drawn off into a large shallow vat, and cooled

sufficiently to precipitate the sodium chloride. After this precipitation, the solution is again drawn off and cooled to a point at which the sodium nitrate crystallises. When the nitrate has crystallised on the bottom and sides of the vats, the remaining liquor is pumped off and the nitrate crystals thoroughly dried and packed for shipment.

Iodine, the most important by-product of the nitrate industry, is extracted from the liquor which remains after the nitrate has been precipitated. Although some sodium iodate is contained in practically all caliche, iodine is produced by only a portion of the nitrate companies, and the output of these companies is carefully regulated by a producers' trust in order that the limited market may not be overstocked. The average pre-war exports amounted to approximately 475,000 kilos annually; but during the War, the exports were much larger: 708,800 kilos in 1915, 1,323,000 kilos in 1916, and 759,000 kilos in 1917. Germany was the principal purchaser of iodine before the War, the United States second, and Great Britain third.

Another by-product, nitrate of potassium, is engaging the attention of various experts. One chemical engineer asserts that this salt exists in the caliche throughout all parts of the nitrate region and that the caliche used by at least a hundred of the oficinas contains from 1 to 2 per cent. An American company is reported to have perfected a refrigerating process by means of which it can manufacture this by-product at small cost.

The nitrate producers are ultra-conservative and have made few changes in the methods of mining and refining caliche since 1884 when the nitrate deposits first came into Chile's possession. According to the best authorities, the waste of nitrate in mining now amounts to no less than 40 per cent. of the total nitrate content of the caliche extracted; and the waste of the nitrate at the oficinas, given in terms of the nitrate content of the caliche brought to the oficinas, amounts to no less than 35 per cent. In 1884, the caliche refined averaged as high as 51 per cent. nitrate content; and, consequently, nitrate production was a profitable industry in spite of the inefficiency of the process used, but now that the caliche averages only 17 or 18 per cent. nitrate content this process is far too wasteful.

The lower yield of nitrate from the caliche, the higher cost of labour and supplies, and the fear of competition of the synthetic product are combining to make the producer anxious to increase the efficiency of the industry. Chemists are at work studying the composition of the caliche and chemical engineers are experimenting with changes in the method on mining and refining. Already some of these experiments have resulted in reduced production costs.

GENERAL NOTE.

Onion Smut.—The occurrence of Onion Smut (*Urocystis cepulae*) is a new disease in this country, says a leaflet issued by the Ministry of Agriculture. For the last fifty years this fungus has been the cause of serious disease in the Eastern States of America, and it is usually regarded as of American origin. When bad attacks occur practically the entire crop may be lost. In parts of America the cultivation of onions over thousands of acres of valuable ground had to be given up. As is the case with Wart Disease, the disease contaminates the land and the greatest difficulty has been experienced in attempts to sterilize the soil. The attacks in England are, at the moment, confined to five centres. They occur in strictly localised areas in the following localities: Near Northampton, near St. Neots, near Kendal, and in market gardens in two districts in Northumberland. If care be exercised, there is no reason why the disease should spread, and if proper measures are adopted it may even be stamped out.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 p.m.:—

April 6.—Archibald Barr, LL.D., D.Sc., Emeritus Professor of Engineering, University of Glasgow, "The Optophone—an Instrument for Enabling the Blind to read Ordinary Print." (A Demonstration of the Instrument will be given.) Alan A. Campbell Swinton, F.R.S., Chairman of the Council, in the Chair.

April 13.—Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., "Low Temperature Carbonisation and Smokeless Fuel." Sir Arthur Duckham, K.C.B., M.Inst.C.E., in the Chair.

April 20.—Sir James Cantlie, K.B.E., LL.D., F.R.C.S., "Thomson's Apparatus for Armless Men." (A demonstration of the Armless Machine will be given.)

April 27.—Sir James P. Hinchliffe, "Research in the Wool Industry."

Indian Section.

At 4.30 p.m.

Friday, April 22.—Lieut.-Colonel Sir Edward W. M. Grigg, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture).

Tuesday, May 3.—William Raitt, F.C.S., Cellulose Expert to the Government of India. "Paper-pulp Supplies from India."

Friday, June 10.—Sir George Seymour Curtis, K.C.S.I., "The Development of Bombay."

INDIAN AND COLONIAL SECTIONS.
(Joint Meeting.)

At 4.30 p.m.

FRIDAY, MAY 27.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced :—

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

DR. C. M. WILSON, "Industrial Medicine."

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

CANTOR LECTURES.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures.

Syllabus.

LECTURE I.—APRIL 11.—Visual and Photographic Methods — Emission Spectra — Flame, Arc and Spark Spectra, as applied to the analysis of complex substances. Comparative methods —Qualitative and Quantitative methods— Vacuum tube Spectra.

LECTURE II.—APRIL 18.—X-ray Spectra. Spectrophotometers, especially Sector-spectrophotometers for exploring the Ultra-violet region. Absorption spectra by old and new methods.

LECTURE III.—APRIL 25.—The significance of Absorption spectra. Studies on the Ultraviolet absorption spectra of Blood Sera, Uric Acid, Cellulose Films, etc. Applications of Spectroscopic Instruments to the technological study of Fluorescence in Paper, Textiles and other materials.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, APRIL 4..Wireless Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m.

Royal Institution, Albemarle Street, Piccadilly, W., 5 p.m. General Meeting.

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Mr. W. Hoste, "Fetichism in Central Africa and Elsewhere."

Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W., 4 p.m. Mr. C. B. Marshall, "The Agriculture Act, 1920."

Engineers, Cleveland Institute of, at the Literary and Philosophical Society, Corporation Road, Middlesbrough, 6.30 p.m.

Engineers, Society of, at the Geological Society, Burlington House, W., 4 p.m.

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, 5.30 p.m. Lieut. J. C. Ferguson, Assoc. G.E., "The Motor Car Pneumatic Tyre."

Chemical Industry, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. Prof. W. Stiles, "The Scientific Principles of Cold Storage."

Geographical Society, 135, New Bond Street, W., 8.30 p.m. Prof. A. W. Gomme, "The Scenery of Greece."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Sir Lawrence Weaver, "The Land Settlement Building Work of the Ministry of Agriculture and Fisheries."

TUESDAY, APRIL 5..Alpine Club, 23, Savile Row, W., 8.30 p.m.

Civil Engineers, Institution of, Great George Street, Westminster, 5.30 p.m. Luke Hamilton Larmuth, Assoc.M.Inst.C.E., "Airship Sheds and their Erection."

Royal Institution, Albemarle Street, W., 3 p.m. Professor R. A. Sampson, F.R.S., Astronomer Royal for Scotland, "Present Position of the Nebular Hypothesis."

United Service Institution, Whitehall, S.W., 5.30 p.m. Lieut.-Commander V. H. Danckwerts, "A Naval Comparison, 1807-1917."

WEDNESDAY, APRIL 6..Faraday Society, at the Chemical Society, Burlington House, W. p.m. "Discussion on "The Failure of Metals under Internal or Prolonged Stresses."

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m. 1. Messrs. F. G. H. Tate and J. W. Pooley, "Detection and Estimation of Illipe Nut Fat used as a substitute for Cocoa Butter." 2. Messrs. T. F. Harvey and S. Back, "The Estimation of Strychnine in Scale Preparations containing Quinine and other Cinchona Alkaloids." 3. Dr. S. Mallaneh, "A Colour Reaction for Aconite." 4. Mr. J. L. Lizius, "A Method for the Determination of the Acidity of Coloured Solutions."

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, Piccadilly, W., 4.30 p.m. Andrew Oliver, "Notes on the Destroyed London Monasteries and Churches."

THURSDAY, APRIL 7..Fine Art Trade Guild, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6.30 p.m.

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace Road, S.W., 6 pm.. Mr. M. Dainow, "Original Research in Vocational Tests."

Automobile Engineers, Institution of, Memorial Hall, Albert Square, Manchester, 7.30 p.m.

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Mr. K. Baumann, "Some Recent Developments in Steam Turbine Practice."

Linnean Society, Burlington House, Piccadilly, W., 5 p.m. 1. Mr. A. Malby,—"A Miniature Alpine Garden from January to December." 2. Mr. H. W. Monckton.—Exhibition of various forms of *Taraxacum erythrospermum*, Andrz.

Royal Institution, Albemarle Street, W., 3 p.m. C. T. R. Wilson, F.R.S., "Thunderstorms." (Lecture I.) (The Tyndall Lectures.)

FRIDAY, APRIL 8..London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. Miss Norah March, "London Development in Relation to Health."

Royal Institution, Albemarle Street, Piccadilly, W., 9 p.m. R. H. A. Plimmer, D.Sc., "Quality of Protein in Nutrition."

Astronomical Society, Burlington House, 5 p.m.

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

SATURDAY, APRIL 9..Chromatics, International College of, Caxton Hall, Westminster, S.W., 3.15 p.m. Rev. J. J. Pool, "The Chameleon and its Changing Colours."

Municipal and County Engineers, Institution of, S.E. District Meeting, Dorking, Conference (Housing and Town Planning.)

Royal Institution, Albemarle Street, Piccadilly, W. H. H. Dale, F.R.S., "Poisons and Antidotes." (Lecture I.)

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FRIDAY, APRIL 8, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, APRIL 11th, at 8 p.m. (Cantor Lecture.) SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and Spectrophotometer to Science and Industry." (Lecture I.) C. F. Cross, F.RS. in the Chair.

WEDNESDAY, APRIL 13th, at 8 p.m. (Ordinary Meeting.) PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Low Temperature Carbonisation and Smokeless Fuel." Sir Arthur Duckham, K.C.B., M.Inst.C.E., in the Chair.

"OWEN JONES" PRIZES

The Council of the Royal Society of Arts hold a sum of £400, the balance of the subscriptions to the Owen Jones Memorial Fund, presented to them by the Committee of that fund in 1876, on condition that the interest thereof be spent in prizes to "Students of Schools of Art, who, in annual competition, produce the best designs for Household Furniture, Carpets, Wallpapers and Hangings, Damasks, Chintzes, etc., regulated by the principles laid down by Owen Jones."

The Council are now prepared to offer six Prizes in 1921 for the following subjects:—

BOOK PRODUCTION AND ORNAMENTAL LEATHERWORK: Including Covers and Lining Papers for Bookbinding, Title Pages, Lettering and Printing, Posters, Trade Labels and Advertisements.

METALWORK: Including work in Precious Metals, Ironwork, Jewellery, Enamelling, etc.

WALLPAPERS, and other Mural Decorations.

TEXTILES: Including Damasks,* Brocades for Decoration and Furniture, Printed Fabrics for Hangings, Vestments and Church Fabrics (including Altar Frontals, etc.), Figured Velvets and Figured Muslins.

Each Prize will consist of the Society's Bronze Medal, and a copy of a book or books on Applied Art, of a value not exceeding £2, to be selected by the successful competitor.

In addition to the above prizes, the Council offer A SPECIAL PRIZE OF TWENTY POUNDS for the best design (irrespective of class) submitted for competition.

The Council reserve the right of withholding any or all of the Prizes offered and they will be the sole judges in each individual case of the qualifications of a competitor to receive an award.

The competition is limited to students of Schools of Art.

No competitor may send in more than a single design for each of the above-named manufactures, but that design may be accompanied by one or two working drawings or other illustrative sketches.

A sample of manufacture executed from the design may be submitted with or in substitution for the original design; but every submitted work must be approved by the Master or other authority of the student's school, who must certify that the design is the work of the student sending it in, and that it has been executed since the last competition in which the subject of the design was prescribed.

No candidate who has already received an Owen Jones Prize for any of the above-named manufactures can take part in the competition.

*Designs for Bed-Spreads, Table Covers, Cushion Squares and Tea Cosies will be eligible.

Competing designs must be sent, carriage paid, and labelled "Owen Jones Prize Competition" on the outside, to
THE DIRECTOR AND SECRETARY,
Victoria and Albert Museum—
South Kensington, S.W. 7.
between June 20th and June 25th, 1921. They may be delivered by hand on any one of the three days ending June 25th.

The sender must also notify the Secretary of the Royal Society of Arts by post that the design has been sent in, and must enclose stamps or P.O.O. for the return carriage.

No special conditions are laid down as to the size or character of the drawings sent in.

The awards will be made by the Council of the Royal Society of Arts on the recommendation of Judges appointed by them.

Arrangements will be made, if possible, for the public exhibition of the competing designs in the Victoria and Albert Museum, South Kensington, as in previous years.

All possible care will be taken of the designs, but the Council accept no responsibility for injury or loss.

PROCEEDINGS OF THE SOCIETY.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 2ND, 1921.

LORD HENRY CAVENDISH BENTINCK, M.P., in the chair.

THE CHAIRMAN said that Captain J. Manclark Hollis, author of the paper to be read, was the very able and energetic Secretary of the Village Centres Council, and it was to a very large extent due to his efforts that the first Village Centre had been started at Enham. He himself was Chairman of the Executive Committee of the Village Centres Council. Some energetic members of the Committee, Dr. Fox and others, investigated the question of disabled men in France and Italy and elsewhere, and they came to the firm conviction that the best way of restoring disabled men to health, vigour and sanity was to combine treatment with vocational training, *i.e.*, that the best way of restoring a man was to give him manual employment with his treatment. With that idea, and thanks to the good work of the Committee and the liberality of the Red Cross and private individuals, sufficient money was collected to buy an estate in Hampshire of a thousand acres, on which were one large country house and two small ones. Some four hundred patients had now been treated and trained, and there were many more waiting to come. The work had been extremely successful, the vast majority of the men being completely restored to health. There were others, however, whom no medical treatment would ever really restore to their pristine vigour. Such men would always have to work in suitable surroundings and in a healthy atmosphere; they would never be able to return to ordinary industrial life in a crowded town. The Village Centres Council, therefore, was not only training and treating men and passing them through the Village Centre, but it was aiming at forming a Colony for the sub-normal men, where they could work under suitable conditions. It had been proved that a man who could not do any work at all really satisfactorily under ordinary industrial conditions could do 100 per cent. of work in suitable healthy surroundings such as those at Enham. That was one of the satisfactory parts of the work, the permanent side of it, and it was being developed as fast as possible. More money was required, and he hoped those present would be able to influence their friends to assist in the good work.

The paper was:—

THE RE-EDUCATION OF THE DISABLED.

By J. MANCLARK HOLLIS,
Secretary to the Village Centres Council.

It is a great privilege for me to come here to-night to tell you about the most interesting work being carried out by the Village Centres Council—interesting, I think, for two reasons. Firstly, because, as I hope you will realise, something concrete is being done to make our disabled men fit and once more able to take their place in the world of industry with their fellow men, and secondly—and perhaps this is of more importance to-day than any other subject—because I hope to prove to you that high war disability men, given proper conditions, can work and turn out as good work as that done by fit men.

I lay emphasis on this second reason because it meets one of the greatest problems with which we are faced to-day. What is to become of the man so injured by War Service that not only is he debarred returning to his pre-war occupation, but, on account of the seriousness and gravity of his wounds, mental and physical, or both, he is debarred from being absorbed through any channels of employment? Yet that man, given proper care and under sheltered conditions, can supplement his pension to no small extent by work suited to his disability. I hope that by the end

of this paper you will realise that the Village Centres Council has set out successfully to solve this particular problem of employment, which threatens, not only a large section of our disabled men, but also, and please note this, a very large section of our industrial workers who, on account of injuries received in trade are, after they leave hospital, unable to return to their work on account of the injuries sustained. For this latter class nothing is being done at present as regards re-education, except, I believe, in Staffordshire. This should not be the case. Every Ex-Service man, as well as every industrial worker, should be taught, while undergoing convalescence, some other trade suitable to the injury sustained, which will not only make him independent, but will make him (or her) an economic unit to the State instead of, as at present, a drag.

Let me now proceed with the actual work being carried out at the Enham Village Centre, the Council's first and, at present, only Centre.

The Council was formed in 1918. Prior to this date visits had been made to the Re-educational Centres for the French and Belgian wounded in France and also to Centres in Italy, and many convalescent homes in this country were inspected. It was thought by the Council that such work in England should be started and carried on a further step by establishing a permanent settlement side at each Centre to cater for the permanently sub-normal or sub-standard man, *i.e.*, the man who on account of his permanent disability would not be able to compete in the industrial world. For this work the Village Centres Council was formed and the details of the scheme delegated to an Executive Committee, now under the Chairmanship of Lord Henry Cavendish Bentinck, M.P.

Many possible sites for the first Centre were visited, and eventually the Enham

FIG. 1.—ENHAM PLACE AND MEDICAL BLOCK (Presented by British Red Cross Society).

Estate, by Andover, Hants, was purchased. The Estate consists of 1,027 acres, comprising four farms, three big houses, one smaller house, village hall, smithy, post office and from thirty to forty cottages. There are also 180 acres of woods and 25 to 30 acres of gardens. I do not want to reiterate the difficulties which faced us when we commenced, as I am anxious to get on to what we are actually doing now and what we hope to do in the future.

However, I feel I must state that we have been enabled, thanks to the generosity of the public, to purchase this Estate for £30,000. The British Red Cross Society has also helped us most munificently.

As we were not in a position to develop the whole Estate at once, we let three of the four farms to tenants for three years; the fourth, comprising some 200 acres, we farm ourselves in order to feed our men, and also for instructional purposes.

Eventually in June, 1919, we opened our doors and received our first pensioners. Since that date nearly 400 men have passed through our hands, and I am glad to state that with few exceptions all the men that have left us are now once more happy and independent citizens of the country for which they so gallantly suffered. At the present time we have 160 men in residence. Our motto for the men who come to us is: "Once an Enham man, always an Enham man," since, as soon as a man leaves Enham, all his papers are sent to the Council's office in London, and from there his welfare is looked after, advice and help are given as far as possible as regards pension, grants and employment.

Now I come to the actual admission of a man to the Centre. He is recommended for treatment and training by his Local War Pensions Committee. An application form is filled in and forwarded to Enham via the Hants' Pensions Committee, and in due course, if he is approved, the man comes

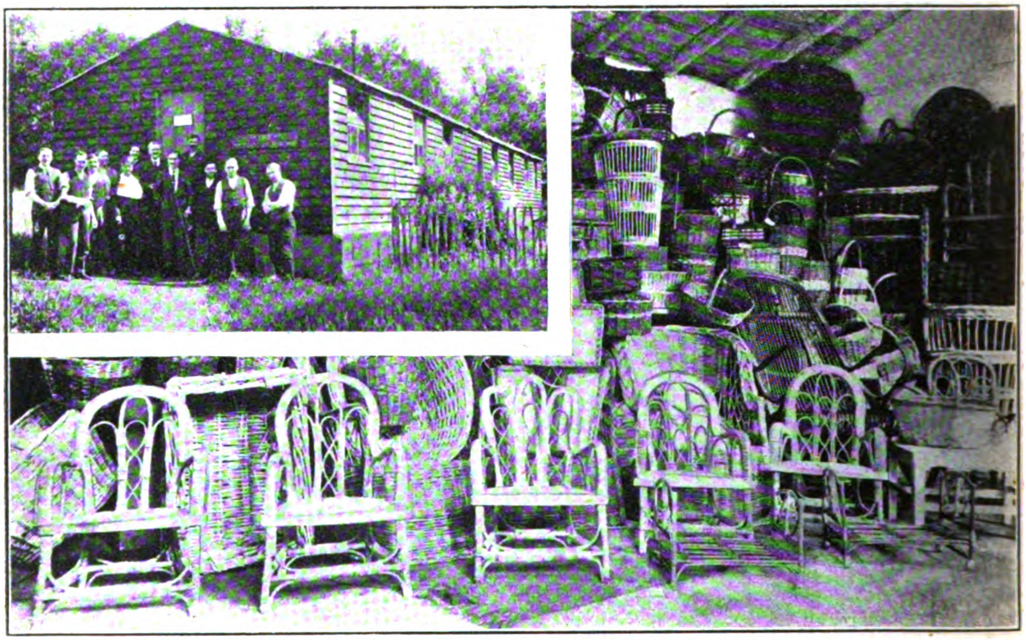

Fig. 2.—Group of Basket Makers and their Work.

to Enham. Convalescent cases of all kinds of disability are taken, with the exception of tubercular and epileptic cases. On his admission to Enham he is seen by the Administrator and the Medical Director, and asked what training he wishes to take up. Sometimes the training for which he asks is not suitable to his disability and he is advised to take up some other. For the first few weeks, as a rule, the man is put on purely curative work in the gardens, woods, or on the farm. When he is considered fit he is put on vocational or occupational training. This commences at four hours per diem and gradually increases as the need for treatment decreases. The treatment consists of graduated industrial training, orthopædic treatment, electro-therapy, hydrotherapy, physcho-therapy, remedial exercises and also vocal therapy for stammering and functional disorders of the vocal and respiratory systems. The mental condition and lack of proportion of a large percentage of the men who come to Enham is really pitiful, but by the above methods of treatment and re-education, they soon pick up and see matters in their right proportion, and also regain their self-control and independence. Training is given in horticulture, farming, carpentry

and joinery, basket making, electrical fitting, boot and shoe repairing, poultry rearing, hand-made furniture, forestry and rural wood industries, *i.e.*, the making of hurdles, hoops, tool handles, ladders, gates, etc. When a man is ready for discharge, he is so certified by the Medical Director and then handed over to the Administrator, who arranges either for his further training under the Ministry of Labour or Agriculture, or for employment. There is a joint administration at Enham, under the Administrator, Major Alan Garthwaite, D.S.O., M.C., who has all the discipline, instruction, training, employment, estate management and the general administration of the Centre under his control, and the Medical Director, Colonel Dansey-Browning, C.B.E., A.M.S., who is in charge of all medical administration and is assisted by a chief medical officer, visiting specialist and a Matron, Assistant-Matron and Sister-in-Charge of Littlecote—the sub-centre for neurasthenic cases.

One of the most active sections of the work at Enham is the recreational side. We have an Institute which was presented to us by Seaford. The Village Clubs Association have recognised our Institute and we are affiliated with that excellent movement. The Institute is run by a

FIG. 3.—CORNER OF BOOT AND SHOE REPAIRING SHOP.

Committee, and billiard matches, concerts, lectures, debates and whist drives take place with great frequency. Then there is the Games' Committee which looks after the cricket, football, tennis, bowls, etc. Both the Institute Committee and the Games' Committee are composed mainly of the men themselves, together with members of the Instructional and House Staffs. There is also an Advisory Committee composed solely of the men and elected by them. This Committee acts exceedingly well and goes a long way to making the Centre the success it is. It investigates any complaints that may be made and if considered justifiable the Administrator is approached and the complaint thoroughly and finally investigated. The Committee also advises the Administrator and Medical Director regarding any small breaches of discipline.

I must pay a tribute to the discipline of the men at Enham. Each man is given on his admission to the Centre a copy of the rules—very short and very simple—and placed on his honour to abide by such rules. I am glad to say that the *esprit-de-corps* is most marked and we have never had cause

to regret allowing the men to judge for themselves between right and wrong.

I would now like to point out the manner in which we get help from the Government. First of all the *Ministry of Pensions.* For each man we receive at Enham we receive a capitation fee and also allowances for out-patients. The man while he is with us receives treatment and training allowances and separation allowances for his wife and children. The capitation fees paid to us practically cover all our maintenance, treatment and training expenses. *The Ministries of Labour and Agriculture* have undertaken to continue the training of our Enham men at their own Centres when treatment has been completed. *The Development Commission* have made us substantial grants for the development of our osier beds for basket-making and our rural wood industries. As mentioned before we have 180 acres of wood and are making money from the sale of the articles we are manufacturing therefrom.

The most substantial help we have received from any other Society is that of the British Red Cross Society. They put down in the first place the sum of £15,000 for the erection, heating, lighting and water supply of our medical block and have recently made us a further substantial grant to enable us to consolidate our present position and extend our work so that we may take in an additional 100 men.

We have now divided our men into three categories as follows :—

A. The men whose treatment and training terminate concurrently and who are perfectly fit once more. These men we endeavour to place in some employment and have so far been very successful.

B. The men who require further training when their treatment terminates. This type we pass on to a Centre under either the Ministry of Agriculture or the Ministry of Labour, according to the training required. At the completion of such training the man is examined by the Advisory Committee governing the trade and if this training is proved to be satisfactory, he is given a bonus at the rate of 5/- per week and a grant for tools. But when a man leaves us to continue training he gets a certificate stating the hours of effective training he has done while with us, and the number of hours is credited to his account and counts towards

Fig. 4.—Horticultural Class.

the bonus receivable at the successful completion of his training at the Training Centre.

C. Under the third category at Enham comes the permanently disabled or sub-standard man. This class includes those with more serious wounds, such as amputation, bad head wounds, or acute cases of shell shock and neurasthenia, and who cannot be absorbed through the usual channels of employment.

It will be seen that our work at Enham can be divided into two distinct sides. The temporary side embodying categories A and B, the permanent side embodying category C. It is our object to deal with this third category and we are trying to establish a Centre or Community, where such men may be provided with cottages and an opportunity of earning their own livings in permanent industries, such as basket-making, carpentry, small-holding and farming, poultry rearing, market gardening, forestry and rural wood industries, etc. It has been proved by the ten to fifteen men we have already settled at Enham with their families, that given medical supervision and sympathetic treatment and sheltered conditions, the solution of the problem of the employable high war disability man (*i.e.*, the man drawing a pension from 70% to 100%) can be found.

When Enham is fully developed we hope to have a temporary side capable of dealing with 300 to 400 men at a time, and a permanent community consisting of 150 to 200 men with their families. This latter side we hope to run on co-operative lines.

Fully to develop this scheme we still require capital. We have already received approximately £100,000 from the public and the British Red Cross Society. We still require another £25,000, and I hope that it may be possible for you here to-night to help us to obtain part—if not all—of this sum. We are most anxious to build fifty or sixty cottages; four we have already completed, thanks to a generous friend, and these four are now occupied by disabled men and their families. Six more are on the point of being erected under the scheme drawn up by the Ministry of Health.

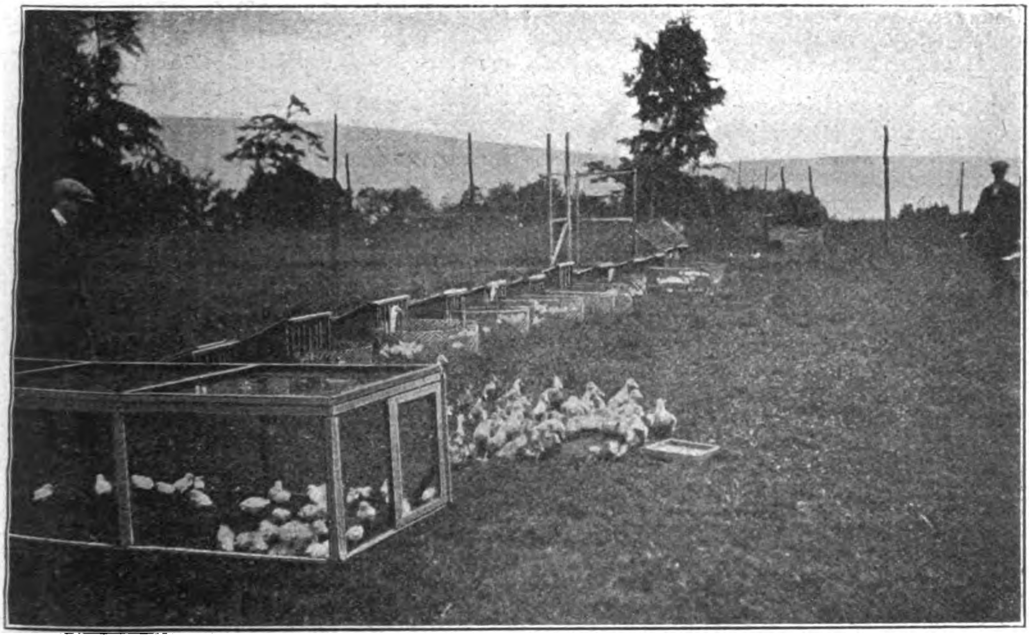

FIG. 5.—CORNER OF POULTRY FARM.

If I have been able to interest you in our work by this paper, I hope you will come generously to our assistance. I dislike begging, in fact it is the only part of this absorbing work that I do dislike, but having served with our men for over five years in France and England, I feel justified in asking you to assist us to carry out our

work to a successful conclusion—especially as we feel we have really now established the first Centre on a sound working basis and have now become a National Institution.

On behalf of all disabled ex-Service men, I wish to thank the Royal Society of Arts for being allowed to come here to-night to tell you what my Council are endeavouring to carry out for the men who served their country so nobly in the Great War.

[The paper was illustrated by a number of very interesting lantern slides.]

During the reading of the paper and the discussion, the chair was taken by DR. WILLIAM GARNETT, M.A., a member of the Village Centres Council, Lord Henry Bentinck having to go to the House of Commons for a time.

THE CHAIRMAN (Dr. Garnett) said he thought the main object of the meeting was to give those present an opportunity of asking the author questions, the replies to which would remove from their minds any possible objection they might have to writing very large cheques for the Enham Village Centre when they went home. He had had the happiness of being associated with the Village Centres movement from a very early date. He had had the particular pleasure of coming frequently into contact with Dr. Fortescue Fox, who, he thought, created the Council. He had seldom met a man with greater courage than Dr. Fox, for with the Council, which had scarcely any resources, he faced the problem of purchasing the Enham Estate at a cost of £30,000, knowing that that outlay only provided an estate with a few empty houses upon it, and that all the money had to be found in order to equip it for the purpose for which it was required. One of the principal difficulties in those days lay with the Ministry of Pensions, who were unwilling to agree that treatment and training should go hand in hand. At the present time the Ministry of Pensions were so keen on that system that it insisted on every man who went to Enham having training and treatment together and going away to some other training centre as soon as treatment was no longer necessary. The great feature of Enham was *treatment combined with training*, and that very strongly appealed to him personally when he was asked to join the Council. He had visited Enham more than once, and on one occasion he surveyed the site for the reservoir and was shown what appeared to be the best pipe-line to bring water back to the house and to the site of the medical building—for it was only a site at that time—and he was greatly charmed with the estate and its surroundings, particularly with the opportunities it offered for forestry and for making articles out of its own grown timber. At that time he was looking forward to taking a very active part in connection with the building and equipment of the workshops that were to be erected. He was especially interested in the electrical workshop and was sorry to hear that even at Enham the training of men in electrical fitting and electrical engineering generally had been so much restricted by the action of the Electrical Trades Union. He had experienced the same difficulty in his work in London and had found it impossible to obtain opportunities for ex-Service men to be trained in electrical engineering. Yet electrical engineering owed its development originally, mainly to the work done in the Universities and Technical Institutes of this country, and of Switzerland, Germany and other countries. If it had not been for that work, electrical engineering would never have made the strides it did in its early days. It was a science and an art that, more than any other he knew of, developed within the places of education and research. Consequently it seemed to him particularly hard that those who wished to go on teaching the subject were prevented by the action of the Electrical Trades Union, which said that in London it would not allow more than 250 men to be trained, whether they were disabled men or not. As he had said, he had hoped to take a very active part in connection with the building of the workshops of Enham, but, unfortunately, he was prevented from doing so by another piece of work which seemed to be rather more pressing and which had equally to do with ex-Service men, and for the last two years he had been unable to join the author in any of the Enham enterprises or even to speak on behalf of the Enham Village Centre. He hoped it would not be long before he had an opportunity of visiting it again and seeing it as a going concern.

CAPTAIN J. M. HOLLIS read a letter from Dr. F. Radcliffe, O.B.E., Visiting Specialist at the Enham Village Centre, regretting his inability to be present at the meeting and testifying to the value of the work carried out at Enham, adding that he hoped those present at the meeting would realise that Enham was doing for a few what it might do for many if additional funds were available.

MR. M. T. GREENWELL asked if Captain Hollis could give him information of any case in which the Electrical Trades Union had stopped the training of men at Enham in electrical engineering.

CAPTAIN J. HOLLIS said if Mr. Greenwell would come to his office on the following morning he would telephone to Major Garthwaite, the Administrator at Enham, who would give a good many examples of what the Enham Village Centre had had to put up

with in that direction. He knew for a fact of one man who came to his office and was told that he could not receive any further training or employment because the trade was full and the Union could not or would not take any more men.

MR. GREENWELL said he would like to offer an explanation. He was the London District Organiser of the Electrical Trades Union, and was also a member of the Local Technical Advisory Committee for the training of disabled men. The author would know, and certainly the Chairman would know, that the Local Technical Advisory Committee had no control over the Enham Centre. As a matter of fact, on more than one occasion he personally had had an application from the then Secretary of the Local Technical Advisory Committee to supply men to Enham as instructors—perhaps the author remembered writing to Mr. Buck with a view to obtaining suitable instructors for Enham—but the men he interviewed on the subject were not prepared to leave London and go to live in the country. He could assure the author and all those present that it was not a fact that the Electrical Trades Union was against the training of men at Enham or anywhere else, otherwise neither he nor his colleagues would be on the Local Technical Advisory Committee. When the Chairman said it was the Electrical Trades Union that had decided how many men were to come into the industry he also was wrong; it was not the Electrical Trades Union who decided, but a Joint Committee composed of representatives of both the employers and the employees.

MRS. M. WITHIEL asked if the majority of the men at Enham preferred an agricultural life or whether on the whole they preferred the manual training that was provided at Enham.

CAPTAIN HOLLIS, said that as the Enham Village Centre was situated in a rural part of the country it had been asked by the Ministry of Pensions and the Ministry of Agriculture to concentrate more on the agricultural training. The large extent of farm land, woods and gardens at Enham made the Centre very suitable for agricultural and horticultural training, and, therefore, special attention was paid to that. He thought, however, that the proportion of men now being trained at Enham was about equal in the various branches of outdoor work and in the manual trades.

MR. GREENWELL asked if the author could say whether Queen Mary's Curative Centres were based upon the experience obtained at Enham. They were centres set up jointly by the Ministry of Pensions and the Ministry of Labour for the curative training of disabled men. There was a large one at Epsom.

CAPTAIN HOLLIS said he had heard from the Ministry of Pensions that the idea was taken from the Enham Centre, which was the pioneer treatment and training Centre in the country. The Centres to which Mr. Greenwell referred had Government funds to draw on and could spend much more money on equipment than the Enham Centre was able to do.

MR. GREENWELL said that was one of the points he wished to touch upon. The Local Technical Advisory Committee came into existence in June, 1919, and, although the Committee had been pressing the Ministry of Labour since that date until about six weeks ago, and although men were in training at the Hackney Government Instructional Factory, in the electrical industry, the Committee had not been able to make the Ministry move quickly enough even to equip that factory. A class had been formed at the factory for electrical meter making and repairing, and when he visited the factory just before Christmas he found that up till then the men had not even had a meter to work upon. They had turned out no work of a constructive nature, and that was all owing to the lack of business ability of the heads of departments of the Ministry of Labour. On the other hand, the Curative Training Centre at Epsom, which was started a long time after the Government Instructional Factory at Hackney, had been fully equipped by the Ministry of Pensions. The electrical shop there had one of the finest electrical installations in the country for teaching purposes. When it was a question of curative training or curative treatment one Government Department was prepared to spend a large amount of money, but in the case of another Government Department, which was turning disabled men out on to the labour market from the Instructional Factory to compete with men who were not disabled, there was not sufficient money to give them a proper training. The result was that after their three years' training these men would be turned out on to the labour market unfit to follow their trade.

LORD HENRY BENTINCK asked if the Government Instructional Factory at Hackney was still inadequately equipped.

MR. GREENWELL replied in the affirmative. Although the Local Technical Advisory Committee decided that it could not take into the industry more than 250 disabled men, there was not sufficient equipment at the Factory at the present time to enable 250 to be trained. There were only about 170 men there at the present time, and it was entirely due to the "mess and muddle" of the Ministry of Labour.

THE CHAIRMAN (Dr. Garnett) said that the remarks of Mr. Greenwell were worthy of consideration and would no doubt receive

attention when they appeared in print. He had very much pleasure in proposing a vote of thanks to the author for his exceedingly interesting paper. He (the Chairman), trusted that the absence of further questions was an indication that all present were perfectly satisfied with the work that was being done at Enham, which had certainly been described in a very charming manner. He would like to say that Captain Hollis was not simply an officer of the Village Centres Council, but was a lover of the work and went into it with his whole heart.

Lord Henry Bentinck, in seconding the resolution, said he would like to associate himself with all the Chairman had said about the devoted service which the author had given to Enham. He was sorry not to hear the whole of the paper, but he was fortunate enough to return to the meeting before the end of it, and he most heartily agreed with the Chairman in thanking Captain Hollis for the admirable manner in which he had described the work being carried on at Enham.

The resolution of thanks was carried unanimously, and the meeting then terminated.

Dr. Garnett writes:—"Unfortunately, I failed to hear most of Mr. Greenwell's remarks or I should have answered some of them from the Chair. I had known that the limitation on the industrial training for the electrical trades had been imposed by a Joint Committee under agreement between employers and employed, and it was through lack of forethought that I referred to the Electrical Trades Union instead of the Joint Committee of the Electrical Trade. The severity with which the restriction is enforced is illustrated by a case in which I was specially interested. A man who had some experience in electrical wiring had returned to London after a long service in Mesopotamia. During that service he had acquired some knowledge of colloquial Arabic. He wished to improve this knowledge by attending classes during his spare time, but to devote workshop hours to industrial training in electrical work. His previous education did not qualify him for a course of University type. It was his intention, on the completion of his course, to return at once to Mesopotamia, where he was confident of earning a livelihood at his trade, but even under these circumstances I was unable to obtain permission for his admission to the only practical classes of the type required in London."

VEGETABLE OIL-BEARING PRODUCTS OF TRINIDAD.

The only vegetable-oil product of commercial importance in Trinidad is coconut oil, the output of which is approximately 140,000 gallons per annum, with a possible maximum, however, of 180,000 gallons. The production is influenced to a very large extent by the prices paid for copra. If the market for copra is relatively high as compared with coconut oil, the tendency is to export copra, instead of using it locally for the extraction of coconut oil. As, however, coconut oil is a necessity in the food diet of a large portion of the local population (including all the East Indians, who constitute about one-third of the population and who will not make use of animal fats) the local government would always insist on a substantial production of coconut oil before allowing any exportation of copra.

According to a report by the U.S. Consul in Trinidad, there are six factories in the Island making coconut oil, the three most important being in the Mayaro coconut district on the east coast, which produce together about 100,000 gallons of oil per year. Of the three other factories, one in Port of Spain produced in 1918 about 25,000 gallons, one in the Montserrat coconut district (in the southern part of the island) about 16,000 gallons, and one in the Cedros district (in the south-western part of the island) about 250 gallons.

The only other vegetable oils produced in Trinidad (and these not in any commercial quantity) are castor oil, obtained from castor seeds, the cultivation of which started to a small extent during the war, in order to meet the great demand for its use as a lubricant for aeroplanes, but in which little or no interest is now shown; crab oil from the seeds of the crab-bean tree, which is used locally for clearing stock of parasites, ticks, etc.; and hunterman's oil, made from the seeds of a large forest liane or rope vine, which is considered a good substitute for castor oil as a purgative.

OILSEED INDUSTRY OF SOUTHERN RHODESIA.

The ground nut, or peanut, is the most important oil-yielding product of Southern Rhodesia. Sunflower seed and linseed rank next in importance, but the latter is grown only for home use at present. Castor beans and sesamum are grown by natives, but only to a very limited extent by white farmers; there is, in fact, little or no trade in these two oilseeds.

In 1918 there were 2,355 acres under the cultivation of peanuts. The yield therefrom amounted to 6,508 bags (83 pounds each). The acreage under sunflowers was 717, and a crop of 1,543 bags (103 pounds each) was obtained. Fifty-nine acres were under linseed cultivation, yielding 59 bags. There are no statistics with respect to the acreage under castor beans and sesamum.

No oil products are obtained from strictly wild growth, although a number of native

oil-bearing plants and trees, including *Trichilia emetica*, occur.

According to the Agriculturist and Botanist of the Department of Agriculture, Southern Rhodesia, peanuts and sun-flower could be produced on an almost unlimited scale if a remunerative market were assured. In fact, production is already increasing, and there seem to be prospects of an extensive trade in both of these oil seeds. An extension of local milling is also expected. However, an increased production of linseed is uncertain.

At the present time crushing is entirely confined to peanuts. There is only one oil mill, and that a small one, at Salisbury. The quality of the oil is reputed to be excellent. The oil content of the local seed is 47 to 50 per cent. in the case of peanuts, 21.4 to 25.5 per cent (54.7 per cent. kernel) for sunflower seed, 28 to 33.7 per cent. for linseed, and 51 per cent. for castor beans.

All the oil, meal, and cake produced in Southern Rhodesia is used locally, and the supply does not meet the demand.

Southern Rhodesia has an area of about 149,000 square miles and a population of approximately 33,000 white people and 770,000 natives. There is a railway running from the southern to the northern border, and again from Bulawayo to Beira in Portuguese East Africa in an easterly direction, but the farms are scattered and situated at varying distances from the railways. In consequence raw material has to be transported to the station in carts pulled by oxen, which is a slow and tedious means of transport.

The natural outlet for most of this territory is through the port of Beira, but a large percentage of shipments, after leaving the Rhodesian Railways, pass over the South African Railways to Cape Town and Port Elizabeth, or less frequently to Durban, or Portuguese East Africa. The first-mentioned route is, however, the most logical, and, according to a report by the U.S. Consul at Johannesburg, there is a growing tendency for merchants to insist upon the continued development of railway facilities in that direction.

In case of shipment through Beira, the ocean communication is through the Suez Canal, except where the destination of the goods is the East.

PRE-WAR OUTPUT OF TURKISH TOBACCO.

According to data collated by the U.S. Bureau of Foreign and Domestic Commerce, before the war Smyrna, Samsun, and Ismidt produced annually some 44,000,000 to 66,000,000 pounds of tobacco. Of this Smyrna supplied about 17,600,000 to 22,000,000 pounds, consisting of two kinds, Bassma and Kalib. Of the former approximately 6,600,000 to 7,700,000 pounds were produced, and of the latter approximately 11,000,000 to 14,300,000 pounds. Bassma tobacco of the best quality is packed in bales of about 33 to 44 pounds, and Kalib in bales of 110 to 132 pounds. There are five sub-classes of Bassma, namely, the Extras, the Bassma Mahssoul, the Sira Pastal, the Ecartés, and the Tongas. The respective pre-war approximate values of these five brands were as follows:—70 to 80 piastres per kilo, 35 piastres per kilo, 25 piastres per kilo, 15 piastres per kilo, and 10 piastres per kilo. (The piastre is normally equivalent to 2.16d.; 1 kilo=2.2 pounds.) The Kalib tobacco had four sub-classes, namely, Kalibs, valued at 30 piastres per kilo; the Kaba Kalib, valued at 25 piastres per kilo; the Orta Mal, valued at 15 piastres per kilo; and the Tonga, valued at 10 piastres per kilo. The Samsun district supplied some 33,000,000 to 39,600,000 pounds, comprising six classess, as follows:—The Indje Bitchak, valued before the war at 45 piastres per kilo; the Orta, valued at 35 piastres per kilo; the Enghin, valued at 25 piastres per kilo; the Baladik, valued at 20 piastres per kilo; and the Guermez, valued at 19 piastres per kilo. The Ismidt district produced some 4,400,000 to 6,600,000 pounds of tobacco. This tobacco, divided as the Samsun tobacco, is stronger and cheaper than the others. During the war production was greatly curtailed. Much of the stocks on hand was allowed to rot because of a decree prohibiting exportation, the loss reaching over 10,000,000 Turkish pounds (the Turkish pound being valued normally at 18s.). Some loss was also experienced because of holding stocks too long in the face of declining values.

NOTES ON BOOKS.

A RESEARCH ON THE EUCALYPTS, ESPECIALLY IN REGARD TO THEIR ESSENTIAL OILS. By Richard T. Baker and Henry G. Smith, F.C.S. Second Edition. Sydney: William Applegate Gullick, Government Printer.

This volume forms No. 24 in the admirable series of technical educational works published in connexion with the Technological Museum, New South Wales. The first edition was exhausted some years ago, and since it was written there has been a great expansion in the employment of Eucalyptus oil in the industrial world, both in connexion with the extraction of metallic sulphides, for perfumery purposes, for solvents and for the preparation of proprietary articles.

The genus Eucalyptus forms, roughly, three-quarters of the whole vegetation of Australia; it contains about 300 species, and is scattered over some 3,000,000 square miles. It is not surprising, therefore, that an account of this great genus should run to about 470 pages. The authors take the various species in sequence.

First is given a general description of the tree, with a note on its fruit and habitat, and this is followed by an account of its essential oil. In cases where the timber is of value, a note is also given of its principal characteristics.

Not the least instructive and valuable feature of the book are the illustrations. Sections of leaves in colour photography, magnified by various diameters, give an excellent idea of the structure and position of the oil glands. Coloured plates are also used to illustrate the appearance of the back of the tree and the grain of the timber, while other plates, both in colour and black and white, are given for purposes of identification. Altogether there are 120 plates. The concluding section gives a good idea of the methods employed for the extraction of Eucalyptus Oil in Australia.

The authors are to be congratulated on the production of a useful and scholarly work, and we join them in appreciation of the far-sighted policy of the New South Wales Department of Education—"a policy that has encouraged and enabled us in our research work, to endeavour to bring to light for the benefit of pure and applied science, some of the hidden mysteries of Australia's unique and wonderful Flora."

GENERAL NOTES.

Sponge Fishing in the Near East.—Sponges are of many qualities, but the most highly prized is that of Syria, with a cuplike shape and a yellowish pale colour, which is found in a number of varieties. The large sponge fisheries are located along the shores of Greece, Syria, and of certain parts of the Adriatic, as well as along the Tripoli and Tunisian coasts. The fishing of sponges is effected by divers who are let down from a boat to depths of 10, 20, and sometimes 25 metres, and pull the sponges from the rocks to which they are fixed. Some sponge fishermen use a long trident, but this system is fortunately falling into disuse since it spoils the sponges. In better equipped fishing grounds, the gathering of sponges is effected by divers provided with diving bells or dressed in cork jackets. Upon being gathered the sponges are squeezed, beaten, and washed in order to rid them of their black coating and soft substance which gives them a very characteristic chlorine odour. When they begin to whiten they are subjected to a frequently renewed solution of sulphuric acid. From data published by the Near East Division of the U.S. Bureau of Commerce, it appears that the sponge-fishing industry in the Near East is especially engaged in by the insular Greeks, particularly of the Island of Hydra, who have long gathered sponges along the Syrian and African coasts. As conducted the work is exceedingly dangerous, and many accidents and deaths occur. The Greek Government, however, has lately taken steps to ameliorate the lot of the divers and thus preserve the industry on which many islanders depend.

New Swiss Process for Watch Regulation.—A discovery that is reported as being capable of revolutionising the watch-making industry has recently been announced by Mr. C. E. Guillaume, Director of the International Bureau of Weights and Measures. A successful method of regulation, remedying the variations in time of a watch due to the expansion and contraction of its parts caused by variations of temperature, is the result of Mr. Guillaume's invention. This so-called "secondary error," writes the U.S. Trade Commissioner at Zurich, has always been one of the great obstacles in the attainment of perfection and precision in watch making, and if this difficulty is overcome the industry should receive very considerable impetus, owing principally to the simplifying of the process of regulation. The chief feature of Mr. Guillaume's new process is a change in the alloy used in the compensating parts. The minimum expansion of nickled steel was found to be increased by the addition of 12 per cent. of chrome as well as a very small quantity of tungsten, manganese or carbon. By mounting a spiral of this steel-nickle-chrome alloy in the watch, according to Mr. Guillaume's announcement, the problem of compensation has been solved and the "secondary error" removed.

Inter-Departmental Committee on Patents.—The Lord President of the Council has established an Inter-Departmental Committee on Patents with the following terms of reference:—(1). To consider the methods of dealing with inventions made by workers aided or maintained from public funds, whether such workers be engaged (*a*) as research workers, or (*b*) in some other technical capacity, so as to give a fair reward to the inventor and thus encourage further effort, to secure the utilisation in industry of suitable inventions and to protect the national interest; (2). To outline a course of procedure in respect of inventions arising out of State aided or supported work, which shall further these aims and be suitable for adoption by all Government Departments concerned. As at present constituted, the Committee consists of the following members:—Mr. Kenneth Lee, (Chairman); Mr. W. St. D. Jenkins, Mr. F. E. Smith, Air Vice-Marshal Sir E. L. Ellington, Mr. H. W. W. McAnally, Mr. P. W. L. Ashley, Colonel W. H. D. Clark, Sir H. Frank Heath, Mr. A. J. Stubbs, Mr. H. H. Dale, Mr. W. J. Coombes, Lieut.-Col. P. K. Lewes, Mr. P. Tindal Robertson, Sir R. A. Gregory, Mr. D. M. Kerly, and the Hon. Sir Charles A. Parsons. The Secretary to the Committee is Mr. A. Abbott, to whom all communications should be addressed at 16 and 18, Old Queen Street, Westminster, London, W.S. 1.

THE INSTITUTE OF METALS.—The Annual General Meeting of the Institute of Metals will be held at the House of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 1., on Wednesday and Thursday, March 9th and 10th, 1921. The Meeting will commence at 10.30 a.m. each day. On March 9th the Annual Dinner of the Institute will be held, and on March 10th there will be a visit to the National Physical Laboratory. The following papers are expected to be submitted in the order given:—Wednesday, March 9th. (*Morning Session*, 10.30 *a.m. to* 1 *p.m.*) (1) "Stages in the Re-Crystallization of Aluminium Sheet on Heating, with a Note on the Birth of Crystals in Strained Metals and Alloys." By Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M., F.R.S., Past-President, and Constance F. Elam, Member (London). (2) "Some Notes on Calcium." By P. H. Brace (East Pittsburg, Pa., U.S.A.). (Presented by Dr. J. L. Haughton). (*Afternoon Session*, 2.30 *p.m. to* 4.30 *p.m.*) (3) "Plastic Deformation of some Copper Alloys at Elevated Temperatures." By Professor C. A. Edwards, D.Sc., Member, and A. M. Herbert (Swansea). (4) "The Action of Reducing Gases on Heated Copper." By H. Moore, O.B.E., B.Sc., Member, and S. Beckinsale, B.Sc. (Woolwich). Thursday, March 10th. (*Morning Session*, 10.30 *a.m. to* 12.30 *p.m.*) (5) "The Season Cracking of Brass and other Copper Alloys." By H. Moore, O.B.E., B.Sc., Member, S. Beckinsale, B.Sc., and Clarice E. Mallison, M.B.E., B.Sc. (Woolwich.) (6) "The Constitution of the Alloys of Copper with Tin, Parts III. and IV." By J. L. Haughton, D.Sc., F.Inst.P., Member (Teddington).

BAMBOO FOR PAPER-MAKING.—On April 19th, 1917, a paper by Mr. R. S. Pearson, F.L.S., Imperial Forest Economist in India, on "The Recent Industrial and Economic Development of Indian Forest Products," was read before the Indian Section of the Society. One of the matters dealt with by Mr. Pearson was the utilisation of bamboo for paper-making. In the current number of the Bulletin of the Imperial Institute it is mentioned that a British firm have been granted a concession for cutting bamboo in the Government forests in Trinidad, and have also established a bamboo plantation there of 1,000 acres. Leases have been granted or applied for, for working bamboo forests in Burma, Madras, and other parts of India. In Indo-China, two factories, equipped on up-to-date lines, are actually manufacturing paper chiefly from bamboo. Paper made entirely from bamboo pulp is of high-class quality. On the whole, it is too good for the manufacture of ordinary news-print, and is more suitable for the better grades of printing paper. The article gives an account of the general characters and distribution of bamboos, and a detailed statement as to their occurrence and utilisation in various countries. The technical side of the subject is fully dealt with, particulars being given of the various methods which have been employed for the conversion of bamboo into paper-pulp.

FRENCH IMPORTS AND EXPORTS.—According to a report recently issued by the French Custom House, it appears that France is rapidly recovering her foreign trade. The value of the imports, during the month of January last, amounted to 1,982,468,000 francs, as compared with 2,495,436,000 francs for the corresponding month of the previous year, showing a decrease of 512,968,000 francs. On the other hand, the exports, which amounted to the value of 1,882,468,000 francs during January last, show an increase of 872,739,000 francs, as compared with 1,009,879,000 francs, the value of exports during the first month in 1920. In 1919, France had the most formidable trade deficit that any great Power has ever had to face, but since then, she has been recovering rapidly. Sixty per cent. of the French imports are raw materials for manufacturing purposes, and only to the value of 125,000,000 francs for fully manufactured goods. The exports are partly food-stuffs, which last year were amongst the chief items of imports. During last January, 537,534,000 francs worth of silks, dry goods, steel and iron ware were exported. It seems probable when the whole of 1921 comes to be reviewed, it will be found that for the first time for many years, French exports will be in advance of the imports.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m.:—

APRIL 13.—PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "Low Temperature Carbonisation and Smokeless Fuel." SIR ARTHUR DUCKHAM, K.C.B., M.Inst.C.E., in the Chair.

APRIL 20.—SIR JAMES CANTLIE, K.B.E., LL.D., F.R.C.S., (1) "Thomson's Apparatus for Armless Men. (2) X-Ray Motor Ambulance Service for the United Kingdom." (A demonstration of the Armless Machine will be given.) THE HON. SIR ARTHUR STANLEY, G.B.E., C.B., M.V.O., in the Chair.

APRIL 27.—SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

INDIAN SECTION.

At 4.30 p.m.

FRIDAY, APRIL 22.—LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture). THE EARL OF LYTTON, Under-Secretary of State for India, in the Chair.

TUESDAY, MAY 3.—WILLIAM RAITT, F.C S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

FRIDAY, JUNE 10.—SIR GEORGE SEYMOUR CURTIS, K.C.S.I., Member of the Executive Council, Bombay, "The Development of Bombay."

INDIAN AND COLONIAL SECTIONS.
(Joint Meeting.)

At 4.30 p.m.

FRIDAY, MAY 27.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

Dates to be hereafter announced:—

SIR HERBERT JACKSON, K.B.E., F.R.S., "Research in Scientific Instrument Making."

JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

DR. C. M. WILSON, "Industrial Medicine."

WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), at the Imperial College of Science and Technology, "Brown Coals and Lignites: their Importance to the Empire."

CANTOR LECTURES.

Monday evenings at 8 o'clock.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D, Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures.

Syllabus.

LECTURE I.—APRIL 11.—Visual and Photographic Methods — Emission Spectra — Flame, Arc and Spark Spectra, as applied to the analysis of complex substances. Comparative methods —Qualitative and Quantitative methods— Vacuum tube Spectra.

LECTURE II.—APRIL 18.—X-ray Spectra. Spectrophotometers, especially Sector-spectrophotometers for exploring the Ultra-violet region. Absorption spectra by old and new methods.

LECTURE III.—APRIL 25.—The significance of Absorption spectra. Studies on the Ultraviolet absorption spectra of Blood Sera, Uric Acid, Cellulose Films, etc. Applications of Spectroscopic Instruments to the technological study of Fluorescence in Paper, Textiles and other materials.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY APRIL 11.. Brewing, Institute of (London Section), Imperial Hotel, Russell Square, W.C. 8 p.m.

Electrical Engineers, Institution of (Informal Meeting), at the Chartered Institute of Patent Agents, 335, High Holborn, W.C. 7 p.m. Mr. F. Creedy, "Some Characteristics and Applications of Multi-Speed A.C. Motors."

Surveyors' Institution, 12, Great George Street S.W., 8 p.m. Mr. L. S. Wood, "The Forestry Directorate in France."

TUESDAY, APRIL 12.. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m.

Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Mr. R. Levy, "Baghdad to Teheran, a New Variation of an Old Theme."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. R. A. Sampson, "The Measurement of Starlight."

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 3 p.m. Annual Meeting.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Mr. L. H. D. Buxton, "The Ancient and Modern Inhabitants of Malta."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8 p.m. Hon. J. McEwan Hunter, "Queensland in the Making."

Electrical Engineers, Institution of (Scottish Centre), 207, Bath Street, Glasgow, 7.30 p.m. Dr. J. Erskine-Murray, "Wireless."

WEDNESDAY, APRIL 13.. Newcomen Society, Caxton Hall, Westminster, S.W., 5 p.m. Mr. A. Seymour-Jones, "The Invention of Roller Drawing in Cotton Spinning."

Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W. 8 p.m. Mr. G. Watson, "A Suggested Programme for Automobile Research."

THURSDAY, APRIL 14.. Pottery and Glass Trades Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m. Mr. G. A. Perridge, "Salesmanship."

Electrical Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Mr. E. A. Watson, "Magnetos for Ignition Purposes in Internal Combustion Engines."

Royal Institution, Albemarle Street, W., 3 p.m. Mr. C. T. R. Wilson, "Thunderstorms." (Lecture II.)

Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m. 1. Mr. F. Twyman, "An Interferometer for the Testing of Camera Lenses." 2. Mr. W. Shackleton, "The Testing of Heliograph Mirrors."

Historical Society, 22, Russell Square, W.C., 5 p.m. Mr. H. G. Rawlinson, "Everyday Life in an English Factory in the East."

Concrete Institute, 296, Vauxhall Bridge Road S.W., 7.30 p.m.

FRIDAY, APRIL 15.. Royal Institution, Albemarle Street, W., 9 p.m. Mr. E. Law, "Wolsey as War Minister."

Metals, Institute of, The University, Sheffield, 7.30 p.m. Mr. H. A. Greaves, "A New Non-Ferrous Electric Furnace."

SATURDAY, APRIL 16.. Royal Institution, Albemarle Street, W., 3 p.m. Dr. H. H. Dale, "Poisons and Antidotes." (Lecture II)

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES

NEXT WEEK.

MONDAY, APRIL 18th, at 8 p.m. (Cantor Lecture). SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." (Lecture II.)

WEDNESDAY, APRIL 20th, at 8 p.m. (Ordinary Meeting.) SIR JAMES CANTLIE, K.B.E., LL.D., F.R.C.S., (1) "Thomson's Apparatus for Armless Men. (2) X-Ray Motor Ambulance Service for the United Kingdom." (A demonstration of the Armless Machine will be given.) THE HON. SIR ARTHUR STANLEY, G.B.E., C.B., M.V.O., in the Chair.

FRIDAY, APRIL 22nd, at 4.30 p.m. (Indian Section.) LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture.) THE EARL OF LYTTON, Under Secretary of State for India, in the Chair.

Further particulars of the Society's meetings will be found at the end of this number.

SIXTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 6th, 1921; MR. ALAN A. CAMPBELL SWINTON, F.R.S., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Andrews, Michael Corbet, F.R.G.S., Belfast.
Barber, Charles Oliver, B.Sc., F.C.S., London.
Bhutt, Professor, B.I., M.A., B.Com., Rajkot, India.
Blanch, J. M., London.
Bruce, John, Aberdeen.
Cruce, Rev. Frederick George Landin, M.A., Southsea.
Gantzer, Joseph Francis, Deoghar, India.
Griffin, Watson, Toronto, Canada.
Hussain, Khan Sahib Shariff, Lal Kua, India.
Lake, George Frederick, L.R.I.B.A., London.
McKay, Percy Hamilton, Kobe, Japan.
Mathur, B.D., Gwalior, Central India.
Ojha, Amrit Lal, Calcutta, India.
Sherwood, William John Lewis, London.

The following Candidates were balloted for and duly elected Fellows of the Society —

Arnhold, Charles Herbert, London.
Bedford, James Edward, F.G.S., Headingley, Leeds.
Pearson, Colonel Henry Lawrence, D.S.O. Singapore.
Sen, Percy Arnold, Lucknow, India.
Stone, Lieut. Ellery Wheeler, U.S.N., R.F., San Francisco, California, U.S.A.

A paper on "The Optophone—an Instrument for enabling the Blind to read Ordinary Print" was read by Dr. Archibald Barr, Emeritus Professor of Engineering, University of Glasgow.

The paper and discussion will be printed in a subsequent number of the *Journal*.

CANTOR LECTURE.

On Monday evening, April 11th, MR. C. F. CROSS, F.R.S., in the Chair, MR. SAMUEL JUDD LEWIS, Ph.D., D.Sc., F.I.C., Lecturer in Spectroscopy, University College, London, delivered the first lecture of his course on "Recent Applications of the Spectroscope and Spectrophotometer to Science and Industry."

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 9TH, 1921.

VISCOUNTESS ASTOR, M.P., and, subsequently, COLONEL SIR CHARLES E. YATE, BT., C.S.I., C.M.G., M.P., in the Chair.

THE CHAIRMAN (LADY ASTOR, M.P.), in opening the meeting, said it gave her great

pleasure to preside on the present occasion. Although it was not a very crowded meeting, she was sure it would prove an enthusiastic one, and the more one saw of life the more one realised that it was not crowds that got things done—it was the enthusiast. She wished to take the present opportunity of thanking Mr. Dewar, the author of the paper to be read, and Mr. and Mrs. Massingham for the splendid work they had done in educating public opinion about the iniquities of the plumage trade. Those iniquities would be realised by any one who looked into the subject with an impartial mind, and if all would look into it in that way she thought the vast majority of the people in the country would be on the side of the Plumage Bill Group. In the House of Commons there were only a few persons who stuck their heads into the sand like ostriches, and they were rather appropriately those who represented the interests of the trade or had in their constituencies people interested in the trade. That, however, was not so in every case, because one Member told her he had no feather votes in his constituency and no interest in the trade, but was against the Plumage Bill on certain technical grounds. She thought he had been over-persuaded on the other side. But nearly all the Members of the House of Commons who looked at the matter from a perfectly unprejudiced point of view had shown that they were in favour of the Bill. She was inclined to suspect any cause the chief support of which came from vested interests, no matter what that cause was. When a person began to talk from the point of view of interest, then one had to look well into the subject on which he was talking. One of the arguments used against the Plumage Bill—and a very telling argument at the present time—was: "Can we "afford, for a purely idealistic cause, to pass anything that is going to cause unemployment?" The author of the paper would contend that the Bill would not cause much unemployment. Personally, she thought it would not cause any at all. We continually heard it said that Members of Parliament were losing their idealism, and one would think so when listening to some of the points of view of certain of her honourable colleagues in the House. But she did not think those people were losing their idealism—she did not believe they ever had any. There was, however, a great deal of idealism still in the House of Commons. Those who supported the Plumage Bill ought to prove now that they were not only idealists but also practical people; they ought to show that, although it was a great ideal to save the lives of the birds, and to stop the horrible torture that was going on, their demands were perfectly practicable. The first time she came up against the fact that a few men in the House could prevent the passing of a Bill that almost the whole House wished for, was over the Plumage Bill. She wished to emphasise that point. Not only the country, but the House, was for the Bill, and it was held up by just a few obstructionists, who had succeeded in blocking no less than ten Bills. In 1911 there were 326 for and 48 against; in 1914, 297 for and 15 against, and in 1920, 60 for and only 8 against. And yet the Bill could not be passed. The House of Lords had passed it twice without opposition. The last time it was before the House of Commons Standing Committee a quorum could not be obtained. The system by which a few Members could block a Bill when the majority of the House was in favour of it, and the majority of the people wanted it, was a farce, and ought to be abolished. She wished to impress upon her hearers that the only real opposition to the Bill came from those interested in the feather trade. They had a perfect right to adopt that attitude if they chose—but they were the only people who were against the Bill. She did not think that even they would suffer in the long run if the Bill were passed, for, in spite of the present "slump" in ideals, she did not believe the righteous were ever forsaken. At any rate, the supporters of the Bill in the House of Commons would do their very best to get it through, and thus help not only the birds but humanity at large, because helping one another to be humane re-acted in other ways. She was deeply interested in the subject, not only for the sake of the birds, but for the sake of human beings and their ideals.

The paper read was:—

THE PLUMAGE TRADE AND THE DESTRUCTION OF BIRDS.

By Willoughby Dewar,
Honorary Secretary of the Plumage Bill Group.

Rather more than eleven years ago, a paper on "The Destruction of Plumage Birds" was read at a meeting of the Royal Society of Arts, by Mr. James Buckland. The paper I am to read to you to-day deals with the same subject. Years have passed, but, though here and there laws have been made for the protection of bird-life, the situation, in essentials, remains unchanged, or has been worsened. Therefore, I shall make no apology for once more calling your attention to the activities of those who are responsible for the annual massacre of the world's most beautiful and most useful feathered creatures, to the results and dangers of their trade, and to the long delayed remedies which we are still urging upon the Parliament and the people of this country.

An apology of another kind I must, however, offer, for I do feel very considerable

diffidence in appearing here in the place of Mr. Buckland. Mr. Buckland's long experience of the methods of the plumage traders, his wide ornithological knowledge, his travels in the distant regions of the earth, and, above all, his bright, burning zeal for right, truth and justice, combined to make him on this question an authority without rival. Those of us who are carrying on the fight to-day are constantly and keenly conscious of the enormous debt we owe to him. His task was far harder than ours, although ours, as we have found, is by no means easy. In the year 1921, it is, however, possible to say that on this subject of protection of birds against the milliner, the public conscience has been definitely aroused, whereas in 1909, when Mr. Buckland read his paper before this Society, it was only just beginning to rouse from sleep, and was wondering whether the massacres of which he told them—massacres of egrets, birds of paradise, grebes and albatross, to mention but four of the species so savagely attacked—might not be simply a part of some nightmare delusion.

Incredulity, of course, still exists. Quite a number of people still find it hard to believe that in a single year some 35,000,000 wild birds' skins have been imported into this country merely to gratify a ridiculous whim of fashion. One lady to whom I once spoke on the matter replied that these things could not be, for she was perfectly certain that the Royal Society for the Prevention of Cruelty to Animals would never allow them to be—a touching tribute to the powers of the body which at all times gives us its valuable and faithful aid, but one which I judge to be in some respects exaggerated. Some, then, may yet be sceptical. They are, of course, the men and women whose one over-mastering desire is to spend life untroubled upon the sofa, but, I am glad to say, that they form a dwindling minority in our midst. On all sides of them are the people who believe that the plumage trade, because it battens on wholesale slaughter, must be either mended or ended.

Public opinion to-day is overwhelmingly in favour of the protection of birds by means of the Plumage Bill, which will be introduced in Parliament this session, and the enormous amount of support we are receiving in practical help, in cash, and in sympathy is, in my opinion, directly due to the work done by Mr. James Buckland as a pioneer. We are reaping where he sowed, yet I should scarcely venture to stand in his place to-night were it not for the fact that I have the support of my friend, Mr. Harold J. Massingham. He, indeed, might well have read this paper, for he is, in fact, part author of it. In one sense, perhaps, it were better to describe him as whole author of it, for, during the eighteen months or so that I have acted as Honorary Secretary to the Plumage Bill Group, he and his wife have constantly provided me with inspiration. That they have drawn much of their inspiration from Mr. Buckland's earlier labour is, I think, certain, and I am sure they would be the first to proclaim the magnitude of their debt.

And now, having given honour where honour is due, I am free to pass to my duties as one of the counsel for the prosecution, albeit but a junior. The plumage trade stands charged before you with the very gravest offence that can be alleged against any individual or corporation. It imperils the existence of the whole human race upon this planet, becasue by its systematic depredations on birds, and, particularly on birds during their nesting and breeding season, it is slowly, but surely, bringing species after species nearer and nearer to extinction in those parts of the world where it carries on its nefarious business. We have it on the authority of the Regius Professor of Natural History at Aberdeen University that "six years without birds may bring the whole of animate nature to an end," and it is with that terrible possibility in view that we are struggling against the vested interests of the plume trader, the barbarity of the plume hunter, and the stupidity of the plume wearer.

A very great part of the battle about the Plumage Bill, when our enemies have condescended to leave obstruction for argument, has, of course, been waged around the question of extermination. The traders and their allies go on the assumption that man and his female mate are cruel creatures, who will not be much moved by tales of cruelty to the fowls of the air. The destruction of a colony of egrets in China—the parent birds wounded yet still fluttering to their young with food; the blinding of decoy birds in India, described by Major Lindsay Smith, of the British Ornithological Union, in the pages of the Journal of the

Bombay Natural History Society; the slaughter and maiming of 300,000 albatross and terns on Laysan Island; these are incidents of commerce which may make the most callous shudder, but, perhaps, there are many of us who can forget our shudders quickly. Horror, except when it is the result of personal experience, is seldom an enduring emotion, and the feather dealers may not be far wrong when they tell themselves that their trade is safe if we can prove nothing against it but cruelty to birds in foreign lands. On the other hand, they see that if mankind can be made to realise its own danger from the incessant destruction of insectivorous birds, their shrift as tradesmen will be short. The majority of men and women, they reckon, may be cruel, or indifferent to cruelty, but touch the human race on a question of self-interest, and humanity is aroused.

Trade apologists, of course, reply with a blank negative when we talk of the dangers of extermination. They exclaim that we cannot point to one single species of bird that they have swept from the earth's face, and they expect us to be abashed. They miss the whole object of our crusade. We desire, not to punish, but to prevent. We of the Plumage Bill Group are very practical people. We are not in the least interested in the dodo or great auk. If the plume hunters have not yet killed the last surviving couple of any particular species, our endeavour is to prevent the hunters from doing so in the future. Whilst a species is still common, we wish to prevent it from being reduced to rarity. When a bird can be described as rare, we want to save it from extermination, and we want to save it equally from the tradesman who would make its last nesting place some hat in an Oxford Street window, and from the pseudo-scientist who would lodge it in a glass case in his study. The Importation of Plumage (Prohibition) Bill guards against both eventualities.

In apportioning the blame for bird-slaughter between the trader and the collector, chief blame does, however, rest upon the former. It is his agents who by wholesale massacre reduce a species to rarity, and it is a commonplace of ornithology that the rarer a species becomes, the more surely it is doomed. The mean-spirited collector, the so-called scientist, who cares nothing for nature and everything for a stuffed specimen, follows gloating in the track of the trader's agent. The one pursues the work of destruction until it ceases to be profitable; the other adds a finishing touch, and between them the sacrilege is complete. If you want a parallel to their partnership in iniquity, you must think first of the German armies sweeping over the fair provinces of France, destroying, until to any normal being it must seem that nothing is left to be destroyed; and then you must think of some tourist arriving in his high power car and pilfering rusty bayonets which have marked the graves of the dead soldiers.

Fortunately for the rest of us, those who take a scientific interest in bird-life, are seldom persons of this selfish type I have described, and it is only against the exceptions that we have to legislate. The traders, on the contrary, are, as far as I can judge, all very much of a piece. All for which they care is that the skins and feathers they receive should be of good quality and should command a ready sale. I do not say that they specially demand rare birds, but they would certainly not be distressed if one came into their hands, and the men who do the hunting for them, natives of New Guinea or half-castes of South America, are scarcely likely to have the expert knowledge which would distinguish between the very rare and the comparatively rare, between the comparatively rare and the common. To the native hunter, a brilliantly plumaged bird is simply a bird to be killed, and then to be sold to some European or Asiatic dealer, or it may be exchanged for rum or opium, for, according to Mr. Walter Goodfellow, who has travelled extensively in Papua, those products of civilisation are freely used as barter in the operations of the feather trade. To this statement, Mr. Goodfellow has also added that he has been "aghast at the wholesale slaughter of these wonderful birds"—the Birds of Paradise—and, when revisiting certain localities, "at their complete extermination or greatly diminished numbers." To his testimony let me add that of Mr. Pycraft, of the British Museum of Natural History, than whom our cause has no sturdier or wiser champion. "It is a fact," he says, "that all the species of Paradise Birds are in a very grave danger of total extermination, unless speedy and effective protection is afforded them."

To many of us, indeed, it is surprising

that these birds still survive at all, and I venture to say that several species would already have disappeared had it not been for the fact that during the war the Port of London was for a long time closed to plumage imports, and that during the period in question, they were given some opportunity to recuperate. The case of these Paradise Birds does, by the way, serve most effectively to nail to the counter the lie about a rare species being of no use to the feather trader. Take, for example, the Blue Bird of Paradise, sometimes called Prince Rudolph's bird. When Mr. Stalker visited New Guinea some years ago, he reported it to be very scarce in all the districts where it was known to exist at all. After a careful search of many weeks, over a great tract of country, only three specimens were sighted by his expedition, yet as Mr. Buckland was to relate, twelve specimens of the birds were not long afterwards to be seen at the warehouse of the trade in Houndsditch. Of these twelve, ten were females or young males, worthless or almost worthless for millinery purposes, and only two were adult, fully plumaged males, fit for fashionable hats. From this instance, it will be seen how utterly wasteful this feather trade is. The Papuan hunter kills a dozen of the rarest of rare birds. Two of them fetch big prices in England, and the rest are either left to decay in a warehouse, or may be sold for about the proverbial price of a sparrow to stick in the bonnet of a charwoman.

But trade advocates such as Mr. Downham, with whose letters to the long suffering editor of the *Spectator* you are doubtless familiar, triumphantly tell the world that there are still Birds of Paradise, not only in Leicester Square, but positively in their native New Guinea. They quite forget to say that of these Birds of Paradise, there are many different species, and they entirely overlook the fact that to the biologist or naturalist it will be a tragedy if any one of them disappears. Those species which inhabit the main land may for a little while yet persist in spite of man's brutish greed, but what of those others whose habitat is in the small islands off the coast? For them there is no natural protection, and the habit of the males of flocking together at the courting season, to display their finery to the females, makes them a particularly easy prey to the hunter. If they are to be saved, the only way to save them is by prohibiting the import of their plumes into this country. Protective legislation at the other end is of no use. New Guinea is not a country where smuggling can be effectively checked, or close seasons rigidly enforced.

Turning to another excuse of the traders for the destruction of Paradise Birds, I have to call attention to the most amazing perversion of truth yet brought to my notice in connection with plumage questions. Last year, a traveller wrote a letter to "The Times," and in the course of it explained that whilst in New Guinea, he had seen the females pairing with males which had not yet grown the beautiful long plumes, now, alas, so familiar wherever fashionable women of the world and half-world congregate. These sweeping plumes to which I refer, are, as is well known, only grown by the male bird when he has come to the proper age of mating, and I need hardly add that they play a great part in attracting to him a partner. The hen is dazzled by the beauty of his appearance, yields herself to him, and so, as far as the plumage hunters will allow, the species is continued. When, however, the hens are found pairing with immature and as yet unlovely males, there is only one reasonable inference. Most obviously, the females are taking, not the mates they would desire, but the only mates they can get. The cause of this behaviour is no less plain. There are no adult males for them in the neighbourhood, or, at least, there are not enough of them to go round, because they have been slaughtered for the sake of those very feathers that are assumed for courtship. This letter to "The Times," whatever its purpose, was, in fact, as striking a condemnation of the plumage "industry" as has ever been published in this country. Now, listen how it was interpreted by our adversaries. The hens, they said, do not mate with the magnificently ornamented cocks, because the latter are already past their prime. Their gay adornment is simply a sign of senility, and, if we kill them, we are in no way endangering the species. This argument, you may think, scarcely needs our serious notice, and, in truth, it seems to rest on nothing more solid than the Gilbertian line about the beauty in extreme old age. In comic opera it would pass, but in a grave scientific discussion it is altogether out of place The least learned among us surely, if dimly,

realises that beauty in birds, as in all animals, including the human animal, is an essential part of the divine device for maintaining life on this planet, and is a symbol of health, exuberance and vitality. At the age or season when bird or animal is ripe for courtship and fit for procreation, it appears in its most alluring state of physical perfection. Nevertheless, here are the apologists for commerce ready to assure us that beauty is useless, even that it is a sign of decay, and that it is quite in the natural order of things for a female to prefer a plain and unattractive male to one which can flaunt before her the gorgeous gifts of God--gifts which through her will be transmitted to the next generation. If for one moment we can accept this absurd and monstrous hypothesis, what are we to make of this world in which we live? At once, it makes nonsense of the whole story of evolution. If beauty is not nature's way to secure the continuance and the improvement of the species, how is it that our own human race has reached its present physical standard? The whole idea is, however, so preposterous that I will dwell on it no longer. To advance this theory of the uselessness of beauty is to insult heaven and earth and their Creator, and what is, perhaps, more to the point, to fly flat in the face of common sense.

Not by any such wild story can the feather dealer save himself from being indicted as an enemy to society. I have spoken of his activities in New Guinea, of what we fear he may do there in the future. Now let me deal with what he has already accomplished in the West Indies. Thirteen out of eighteen species of humming birds have been exterminated in Trinidad alone. Possibly they may still be found on the American mainland, but that is wholly beside the point. If our song birds were exterminated in our English woods, or we had no more starlings to guard our English farmer's crops, it would be poor consolation to tell us that there were plenty in some other country beyond the sea. Incidentally I must remark that when the Plumage Bill is passed, when we have secured a new measure of safety for the brilliant birds of India, our tropical colonies, and foreign lands, we shall have to be more than ever watchful over our birds at home, for it is certain that the trade will turn covetous eyes upon them. Last year, a Cheltenham correspondent told me he had seen a woman's hat decorated with a wreath of familiar finches. Only a few weeks ago, that great orator, Lord Buckmaster, in the course of a speech on this subject, mentioned that he had once heard of a creature who had the whole front of her dress made up of the red breasts of robins. Some who heard his story, may have hoped that, since it did not come from his personal experience, it was incorrect. Unfortunately, I am in a position to verify the whole hideous narrative. The creature who so garbed herself, who so degraded herself in the eyes of God and humanity, was a member of my own family.

To return again after this digression to the West Indies. When the whole question of plumage legislation was considered some years ago by a select committee of the House of Lords, some very valuable evidence was given by Lord Stanmore. It is due to him that we know why the humming birds of Trinidad, of which island he was Governor, have been so terribly reduced in numbers, some species vanishing altogether. Orders, he said, used to arrive from New York for as many as 15,000 humming bird skins at a time. He endeavoured in vain to stop the slaughter. When he put a heavy export duty on the skins, commercial influences were, of course, brought to bear on the Colonial Office, and the duties had to be withdrawn. His effort to save the West Indian birds was made over half a century ago, and, no doubt, our adversaries will wish it to be dismissed as an old story. Certainly, it is an old story, but it happens to be one which has constantly been repeated. Each time that an endeavour is made to save bird-life, those "commercial influences," which checkmated Lord Stanmore assert themselves again, and so the traffic in blood and feathers continues. Or, at least, it continues in the markets of Europe. I have spoken of New York as the city to which the skins from Trinidad were sent in the past, but it is only fair for me to add that in the United States most drastic plumage laws are now in force. The Americans to-day protect their own birds and also prohibit the importation of plumes and skins from abroad. The woman who enters the American Custom House with an "aigrette" in her hat is soon shown how a good pair of shears will purge even the most expensive millinery of offence. In this country we do not press for quite such strong measures. Whilst

we wish to prohibit the commercial importation of the plumes of wild birds, we do not propose to interfere with the lady who arrives from the Continent with a feather on her head. She will, so to speak, be cured unofficially of her folly. When there are no more feathers to be sold in the London drapery stores, the drapers will soon see to it that feathers are no longer fashionable.

In other respects, the American example is one for us to follow closely, but in the United States the plumage prohibition laws were passed only just in time. In Florida especially, the commercial hunters had been destructive. Early in the present century, Florida was almost swept clean of egrets, colony after colony of these birds being butchered at the breeding season to obtain those feathers which in the trade are falsely described as "ospreys," and which the egrets only wear at and about the period when they are courting or have their eggs or young. But, as was only to be expected, the trade then, as always, pleaded "not guilty." Their agents, they declared, were not responsible for the disappearance of the birds. The egrets, they said, had disappeared on account of the draining of the Everglades, the swamps in which they had had their homes. This story was rather more plausible than are most, coming from the same interested source, but it has two weak spots. It is more than dubious whether one single egret rookery ever was drained, for, as Dr. Hornaday, Director of the New York Zoological Park, has observed, "the drainage of the Florida Everglades has been a failure and a farce." Secondly, I was very glad to hear last year from Mr. Pycraft, that the numbers of the egret in Florida are once more increasing. Some few birds must have actually survived the period of persecution, and their descendants can now increase and multiply under the protection which American laws afford them.

In the United States the battle for the birds was at least as hard as in this country, and before it was won the plume hunters had murdered one or two of the wardens appointed by the Audubon Society for the protection of the egrets. This, again, is an old story, and one of which the black-coated traders in our civilised cities hate to be reminded, but, though it be well known, I do not hesitate to give it passing mention, for, to quote Paul Déroulède, "the hammered nail only enters the further." May I, also, as I have been speaking of America, repeat to you Dr. Hornaday's advice to the British public, given by him in the columns of the "Nineteenth Century"? "Do not be hoodwinked," he says, "do not be cajoled, do not be deceived by the feather trade and its shrewdly constructed Committee for the Economic Preservation of Birds into giving the horrid trade a long lease of life whilst ponderous and slow running gentlemen are studying and investigating and reporting upon ways and means to raise in captivity, for their plumes, the impossible egret, the unattainable birds of paradise, and the elusive crowned pigeon and eared pheasant. If you feel like shutting your teeth and deciding once for all that the trade shall go on because it wants the money, do it resolutely and shamelessly, with your eyes open; but *don't* do it because you have been hoodwinked and deceived into thinking that the feather trade's plausible committee is really going to raise tropical birds by the million for the supply of the milliners of the world." To Dr. Hornaday's words of wisdom I can only add a single sentence, spoken to me last year by the Secretary of State for India, at a time when there was some question of a compromise between ourselves and the traders. "If," he said, "you allow them one chance out of a thousand they will only rear their ugly heads again."

Compromises of many kinds, all unsatisfactory, have been suggested, and with these I propose to deal a little later on, but before I touch on what the trade proposes to do, I must say something more of what it has done already, for in no other way can I hope to make you realise what manner of trade it is. The figures from its catalogues used to be instructive, but in these days the gentlemen of Houndsditch either think that printing is too costly, or else have decided that it is unwise to boast openly of the extent of the slaughter perpetrated for their benefit. Anyhow, catalogues do not seem to be available now for the general public, and, instead, we are given leaflets on unnatural history, in which an attempt is made to calm the feelings of women who have been told by "cranks" like Mr. Massingham and myself that gulls do not usually moult whole wings, and that birds of paradise are not commonly reared in the backyards of Finsbury. For figures, therefore, I must

go to the last year before the war, but, at the same time, I can say, from observations of millinery made in 1920 and 1921, it is perfectly evident that there has been no decrease in the general butchery. In any single year there may be an unusually large supply of one particular species, but, if five or ten different species are taken together, there will be no great difference between the totals of one year and another. Many birds, it is true, are growing rarer and harder to find, but the hunt for them grows proportionately keener, and new and cunning methods for their destruction and ensnaring are invented. So far the traders have not killed their own trade, but their latest available list suggests that they must be well advanced in that direction. The old-established firms, no doubt, face the future with complacency, for their fortunes are already made, but I would not advise any young man to invest his money in feathers. If the Plumage Bill does not halt him speedily, he will anon be halted by Nature's inability to make good the ravages of "the pimp of fashion."

At the June feather sales in 1913, in London, 77,000 egret skins, or their equivalent, were advertised for sale; 6,328 crowned pigeons; 162,750 Smyrnian kingfishers; 40,000 condor quills. At other London sales that year offers were made of 5,140 crowned pigeons; 5,321 white terns; 1,233 smuggled emu skins; 16,211 white crane wing quills; 19,125 mullet hawk wing quills; 10,800 bustard quills; 1,203 greater bird of paradise skins. Among lots for which there were no buyers may be found many hundred skins of the Impeyan and Lady Amherst pheasants, pelicans, marabou storks, scarlet ibises, owls, eagles and macaws. These numbers are rather staggering. Few, if any, of the birds I have named can be described as common, and some are extremely rare. But rare or common, the slaughter is disgusting. These birds, remember, were not sacrificed for food or warmth for human beings; they were killed merely to put money into the pockets of a few men who exploit woman's atavistic tendency to deck herself with scalps and such-like tokens of butchery. Please do not think I am attacking women. Many who wear plumage are only thoughtless, and the rest, I suppose, have in their composition a "suppressed wish" for the life of Red Indian squaws, and can only satisfy it at their milliners' establishments. But, if only for the sake of those other women who feel shame and horror at these wanton massacres of the innocent, I trust we shall soon have our prohibitory law. Now that women have full citizenship, the foolish and the cruel among them must no longer be allowed to shame their sex. When I hear of some fashionable preacher denouncing the brevity of skirts or the scantiness of blouses, I grow impatient with masculine folly in such matters. And on this point I must quote a few lines from Browning. They are from "The Lady and the Painter," and it is the painter who speaks thus to the lady who in her hat has "wild birds' wings":

"Then, Lady Blanche, it less would move
In heart and soul of me disgust
Did you strip off those spoils you wear,
And stand—for thanks, not shillings—bare,
To help Art, like my model there.
She well knew what absolved her—praise
In me for God's surpassing good,
Who granted to my reverent gaze
A type of purest womanhood.
You—clothed with murder of His best
Of harmless beings—stand the test!
What is it *you* know!"

Men's diatribes against woman's way of clothing herself are secular. They are the one "stunt" of which the public never seems to weary, but the crusade against feathers stands in a class by itself. Side by side with Browning's words upon the subject I would put a recent declaration by the Bishop of Durham, who, in the course of an address he delivered at Sunderland, spoke of the terrible irony of the spectacle that would be presented this Easter when hundreds and thousands of women would be bending their heads before the altar, and on those bent heads would be displayed the tokens of their callous disregard for suffering. All such preaching, however, is in vain, unless it is followed by legislation. Moral suasion has failed, and we must have compulsion. The traders, of course, say: "Refer the matter to the League of Nations;" in other words, postpone it to the Greek Kalends. Already we lag behind the United States of America, Australia, Canada and New Zealand. It is not worthy of the British name for us to wait until every other land has come into line with these progressive countries. In abolition of the slave trade we gave a lead to the United

States, and we did not think it necessary to wait upon the pleasure of the minor South American republics. A trade, merely because it adds something to our figures of exports and imports, is not necessarily to be encouraged. If it is undesirable, it must be crushed. Otherwise, I can see no reason why we should not attempt to wrest from Germany her old supremacy in the production of pornographic picture-postcards. We must repress the feather trade because that is the only way of keeping the birds, and we dare not risk half-measures. The Economic Committee for the Preservation of Birds, which tried both to satisfy protectionists and destroyers, ended in ignominious failure. Last year we heard nothing of it at all, and one eminent scientist who for a time belonged to it, has now signed a petition for prohibitory legislation on the lines advocated by Mr. Massingham and myself. The French naturalists said to this Economic Committee: "Stop the trade first; afterwards we will examine the conditions under which you propose that it should be carried on." That, clearly, is the way of wisdom. In the future, it may prove possible to domesticate other birds as well as the ostrich, but even then wild birds will need protection in their natural surroundings. Farms and sanctuaries, necessary as the latter are, can only be described as makeshifts, for it cannot be forgotten that birds harboured in them depart quickly from the wild type if the circumstances of their existence are radically altered, whilst their offspring may develop yet more divergent characteristics. Worse still are all schemes for transferring exotic specimens from one land to another. What we want is to guard birds against man's desire to get rich quick at their expense, but as far as possible to leave them at liberty, and to the performance of their natural and useful functions.

Unfortunately, there is an idea in many minds that whilst the wearing of the egret's nuptial plumes — the "ospreys" of the trade—is reprehensible, there is no harm in using other feathers for personal adornment. How the notion has gained currency it is difficult to determine. Some of my forerunners, though not Mr. and Mrs. Buckland, were, perhaps, to blame for writing and talking too much about this one sorely persecuted bird, and the upholders of trade interests have not been slow to take advantage of their mistake. They, too, have concentrated upon the egret, and have prepared some kind of a defence for the exploitation of its plumage. If you speak to them of most other birds, they shrug their shoulders, but when the egret is mentioned they are invariably voluble. Realising that the world really has been disturbed by accounts of its slaughter, they prefer, indeed, not to mention it by its most familiar name, and in their jargon it becomes either the "osprey" or else they spell it a-i-g-r-e-tt-e, presumably on the ground that "it doesn't sound half so improper in French." Spurgeon, the great Calvinistic preacher, used to say that those men and women who were doomed to eternal damnation would, no doubt, be treated by the Almighty, in the world to come, "with the utmost consideration," and, according to the traders' tales, this particular bird receives the same consideration in its present existence. Not very long ago, kindly women were assured by their milliners that the aigrette plume (French spelling and pronunciation) was an artificial product, made of horse hair or I know not what. That was lie number one, and is now acknowledged to have been such. Deception number two was exported to Europe by an individual living in Venezuela, and it was specious enough to satisfy even so eminent an authority as Mr. Downham, for the latter quotes it gravely in his book on the feather trade—the book which has come to be the feather trader's bible, though Mr. Massingham and others have questioned how much of it is canonical and how much of it apocrypha. Anyhow, in the story in question, we were told how a bird called the "tordito" was in the habit of pilfering the egret's feathers in order to line its own nest, and that from these nests they were obtained by the plume hunters. This was a very good story. If accepted, it threw to the ground every charge of cruelty; but it had just one weak spot. Neither in South America nor any other part of the world does such a bird as the tordito exist. It had simply been invented for the occasion. To-day, of course, it has a kind of life comparable to that of Frankenstein's monster. It pursues, and will continue to pursue, its creators, and it is particularly active whenever they have a new tale to tell about the humane and gentle methods of their business.

Past experience certainly leads one to

be extremely sceptical of the trade's excuses for itself. When the tordito had served its purpose, the traders next proclaimed that the egret used its own plumes to line its own nest. In this statement there was no grain of truth at all, for the egret constructs its nest of sticks alone, and never thinks of giving it any lining. Nevertheless, this report was circulated over the name of M. Léon Laglaize, described, like the author of the tordito myth, as an eminent entomologist, and here let me mention, in passing, that when our adversaries quote a "scientist" against us, it is ten chances to one that he is an authority, not on birds, but on beetles. These things, as I have said, make us suspicious, even incredulous, of the latest yarns about moulted feathers, farms, and other means of obtaining the egret's plumage without killing the bird. All the same they ought to be given some consideration.

I will, therefore, give some brief criticism of the alleged protection of the egret in Venezuela. In a recent year, I note, the value of the plumage exported from that country to Britain was £77,837, and, supposing it to consist mainly of egret plumage, it must mean that the feathers of over a quarter of a million of these birds were received within the space of twelve months at the Port of London, and in previous years the supply had been far larger. But these are all, or nearly all, moulted plumes, according to the statements of the trade, and it is my business to explain why we of the Plumage Bill Group are of an altogether opposite opinion. In the first place, I am quite ready to acknowledge that a Wild Bird Protection Act does exist in Venezuela, but the Venezuelans, though in many ways delightful people, have the scantiest respect for law and order. If you will read their history, you will find that they contrived to crowd seventy-five revolutions into seventy years. Dr. Mozans, who some years ago wrote a most interesting book dealing with this republic and his experiences therein, remarked that few lands were better governed in theory. "The Constitution," he said, "is modelled after that of the United States, and the laws are largely based on the best legislation of other countries." "But," he added, "this is not sufficient. Of this unhappy country, and especially of its rulers, one may exclaim in the words of the great Florentine poet :—

'Laws indeed there are.
But who is he observes them ? None.' "

However, this law on which the traders base their case deserves some further examination. It is dated June, 1917, and it forbids the killing of the large white egret, or heron, for its plumes, and lays down that its feathers may not be offered for sale without an official certificate to the effect that they are moulted. Further, this certificate has to be produced when each consignment is brought to the Customs House for exportation. So much for the law as it stands on paper; now for the ways in which it is evaded. Venezuela is a very large country. Its area is about three-and-a-quarter times that of the whole of the United Kingdom, and its population is considerably less than that of Wales. Quite apart from the number of revolutions it has experienced, it cannot be an easy land to police, especially as a great part of its area is swamp and virgin forest. Of enormous tracts of the interior practically nothing is known. One American traveller, when at Caracas, the federal capital, could find no one to tell him how a journey could be made between the two inland towns of San Fernando de Apure and Ciudad Bolivar, both of which lie in the region whence plumage is exported. Either could be reached from Caracas, but the ordinary Venezuelan had never dreamed of the possibility of going from one to the other. Such being the state of the land, there must surely be ideal facilities for poaching, snaring and shooting, and we may be confident that, law or no law, the egrets are regularly massacred at the breeding season to obtain their plumes. The man who wants a valuable feather will find it much easier to kill a nesting bird than to wait until the bird drops its feathers in the jungle or upon the face of the water; and he need have no great fear of Venezuelan policemen spoiling his aim with a tap upon the back. Common sense is here our only necessary guide.

Mr. Downham, by the way, assures us that the landowners—swamp owners might be a better word—protect the egrets themselves, and once again he takes the author of the tordito legend as his authority. The latter goes so far as to assert that "imprudent people" who would meddle with the birds "have paid with their lives" for their temerity, or, to put it in plain language, have been shot by the

landlords. Here, truly, is a statement to make us think. Can we really believe that these gentlemen, who take human life so lightly, are so very much more respectful of the life of an egret? To the trade, however, one last line of defence is left, and its apologists will say that the birds are not killed, for the very good reason that only moulted feathers can be exported to the European markets. This would be true enough could we depend either on the patient industry, or the honesty, of the Venezuelan Customs House Authorities. On the first point, I doubt whether they would, or could, make more than a cursory examination of the quantities submitted to them for inspection. As to their honesty, it is a marketable commodity, and Dr. Mozans, in the book I have already cited, lets us know that smuggling is one of Venezuela's key industries. In some cases, he says, the smugglers elude the vigilance of the Government officials altogether, whilst in others they have an unofficial understanding with officialdom, this being obtained by the use of what we know in the vulgar tongue as "palm oil." Therefore, I give it definitely as my opinion that, as nothing but a tactful bribe stands in the way, vast quantities of the plumes which reach London from the Venezuelan ports are plumes obtained by the butchery of the birds that at one time bore them. Remember that large numbers can be packed into a tiny space. I know of a very recent case of the captain of a South Atlantic liner returning to England with a drawer full of "aigrettes," and offering them for sale on the voyage to the women passengers.

Mr. Downham—I really cannot get away from him—told us in a letter to the *Spectator* last summer that at least 70 per cent. of the feathers sent from Venezuela were moulted. In 1908, nine years before the passing of the Act I have just mentioned, Mr. Downham in evidence before the House of Lords Commission put the percentage of moulted plumes at between eighty and ninety. By his own showing, then, this wonderful protective law has done no good at all, and I feel justified in asking you to think that as regards all the facts and figures of the case, he has been utterly misled. In place of his testimony, I ask you to accept the word of the British Minister to the Republic, who stated that "the vast majority of the egret plumes exported to Europe, are obtained by the slaughter of the birds during or about the breeding season, and that no *effective* regulations exist or, indeed, owing to local conditions, can exist for the control of the slaughter." That is disinterested evidence, clear and strong, and Dr. Mozans, the American, writes to the same purpose. "The worst feature about the business," he says, "is that the birds are killed during the mating and breeding season. Already the result is manifest in the rapidly diminishing numbers of egrets that frequent the garceros." A garcero, I should mention, is simply a place where the egrets habitually congregate.

Very possibly some moulted plumes do reach this country, and I suspect that a special effort has been made by the London dealers to obtain a supply of them for exhibition purposes, and to place before naturalists as evidence for the defence. Within the last few months, specimens have, I understand, been submitted to the British Museum, but I do not know when their collection began. We have been hearing of the moulted plume for the last dozen years, and, because one authentic consignment has reached the Museum authorities, there is small reason to suppose that any large number of the "ospreys" in this season's millinery have dropped from the birds in the course of nature. On the contrary, there is every reason to fear that most of them have been obtained by methods of the most infernal cruelty. In case you do not fully understand what these methods are, I will read you an extract from the sworn evidence of one Meyer, a former plume hunter in Venezuela. "The natives of the country," he says, "who do virtually all the hunting for feathers, are not provident in their nature, and their practices are of a most brutal nature. I have seen them frequently pull the plumes from wounded birds, leaving the crippled birds to die of starvation, unable to respond to the cries of their young, which were calling for food in the nests above. I have known these people to tie and prop up wounded egrets on the marsh, where they would attract the attention of other birds flying by. These decoys they keep in this position until they die of their wounds or from attacks of insects. I have seen the terrible red ants of that country actually eating out the eyes of these wounded, helpless birds that were tied up by the plume hunter." This same eye-witness of these atrocities adds that in

the neighbourhood of the breeding places a few feathers may be occasionally picked up, but they only fetch about one-fifth the price that can be had for feathers torn from a dead or wounded bird. There is, therefore, a sound commercial reason why the Venezuelans should kill the egrets and not wait for them to drop their plumes. The case against the trade as regards Venezuela can be completed by the evidence given by Mr. Pam, a member of the Council of the Zoological Society of London, who told the House of Lords Commission that if one wished to collect moulted plumage, one would have to walk several hundred yards for each individual plume, and that in the jungle of the Amazon this would be no easy matter. However, the plumage trade in England has for some time past been fighting desperately for its life, and doubtless its agents in South America have gone to immense trouble to obtain for it sufficient specimens to bemuse the greenhorns of Europe.

Common sense is on our side in this struggle to preserve the birds of the world, but against us are all the forces of sentimentality and fanaticism. Sentimentality is against us, because there aré always so many dear, kind people who look the other way when one asks them to face an unpleasant fact. They cannot bear to think of pretty things being obtained by cruel means, and when some narrative of cruelty is recounted to them, they reply that it is too horrible, and that it cannot be true. The stories told them by the traders are so much nicer than any we have to tell, and they are immensely comforted when somebody slips into their hands an anonymous pamphlet telling them that the Venezuelan law has protected the egret for the past twenty years. Of course they do not know that the law was passed only four years ago, nor do they dream that it was then passed, not for the sake of the birds, but because it would serve to soothe humanitarian feeling in the West End of London. Venezuela is an impecunious State. It derives a good revenue from its plumage exports. It does not want to lose revenue through European women refusing to wear upon their heads what the Canadians call "the badge of cruelty." When the Canadians held their exhibition of war trophies in London, a place was reserved for a headdress trimmed with "aigrettes" that had been worn by one of the Hohenzollern Princes, but, unhappily, we cannot say that the Hohenzollerns are the only people who adorn themselves thus monstrously.

Fanaticism, as well as blind-eyed sentimentality, is against us in this battle. Of fanatics, of course, there are many different kinds, religious, political, artistic, and scientific, but of all fanatics the worst is the commercial fanatic. The merchant in "Timon of Athens" put his creed into a single sentence: "If traffick do it, the gods do it." Therefore, we who would curb traffic, are cursed for our audacious impiety, and told in the sacred name of business to hold our peace. The plumage trader has his religion and his philosophy, and how they differ from ours can, perhaps, be explained if I say that whilst we believe in use, he believes in utility. We feel that the earth and all its glories are for us to enjoy, and to enjoy intelligently: he holds that everything created, everything, if you like, evolved, is for him and his kind to exploit profitably. The bird we call the bird of paradise exists, in his opinion, for no other purpose than to be purchased by some "pretty lady" of the night clubs. The egret—"half angel and half bird"—has, according to him, been provided by the Creator that its nuptial plumage might whiten a sepulchre of dissipated human beauties. The eagle, the hawk, the humming-birds, the gulls—our friends of the London bridges—all, most providentially, have their being on this planet that he may pluck them, or kill them, or hew off their wings, and that their "produce" may be skewered on hats. Were there no other reason to condemn his trade, I would denounce it on æsthetic grounds. A bird is a thing of incomparable beauty whilst it has its powers of flight, its exquisite grace of movement, and, perhaps, its gift of song, but dead, motionless, and dumb, it is merely pathetic, or, when it has been through the hands of the "plumassier," ludicrous. As part of the adornment of an earth-walking woman, it cannot be beautiful, because it is obviously out of place. Eyes which are beads, quills torn from carrion, wings which will fly no more; these are nothing but travesties of nature's loveliness, pitiful and contemptible.

The traders and their accomplices do not use the gifts of God: they abuse and fritter them, but in their eyes all is well, because all is done in the way of business. Rest assured that the Holy Spirit will

never again descend upon mankind in the likeness of a bird, for in the twentieth century it would be sacrificed to the requirements of the feather warehouse of Houndsditch. Instead, however, of considering what the plumage trade would do, I must return to consideration of what it has done already. I have said that its operations endanger the safety of the human race, and of this truth a glaring example is provided by its work in Africa. The welfare and progress of that Continent depend to a large, perhaps an incalculable, extent on various species of insect-eating birds, many of which are destroyed to meet the demands of fashion and the greed of the curiosity hunter. Sir Harry Johnston has provided us with a list of them, and it includes glossy starlings, bee eaters, kingfishers, rollers, egrets, fly-catchers, drongos, trogons, guinea-fowls, francolins, swallows, shrikes, barbets and others. Most, or all, of them prey upon the detestable tsetse fly, the larger blood-sucking gad flies, midges, sand flies, and, above all, upon those degenerate spiders which are called ticks, and which almost rival the tsetse fly in their ability to convey at present incurable diseases both to man and beast. Sir Harry Johnston has said that it is practically to birds alone that we can look for a check upon the tick plague. Also, the part played by birds in the destruction of the mosquito, and by aquatic birds, such as the ibises and flamingoes, in the destruction of mosquito larvæ, must not be overlooked. In Africa, and, indeed, in all tropical lands, a rich bird-life is of even greater importance than it is here, but because the birds of the tropics are often more brilliantly plumaged than are ours, they have to suffer annual persecution. They are utilised for trade and fashion, and trade and fashion thus combine to let loose upon the world plague, pestilence and famine. Yet those who lift their voices against this criminal folly are told they must not interfere with a great British industry. Such is the fanaticism of commerce.

As a matter of fact, the fancy feather business is neither great nor British. The ostrich feather industry, which depends on the careful farming of the birds, should be regarded as a thing apart, and nobody wishes to interfere with it. The average annual import of feathers, other than ostrich, into this country is valued at about £1,000,000. The general bulk of this plumage is usually bought in London by Continental dealers, who take it abroad at once, so that no British labour is used upon it. Of the remainder, the greater parts consist of farmyard produce, feathers of poultry, which under the Plumage Bill would continue to come into the country, and of dressed feathers which, again, provide no employment here. British labour in fact—and I am not sorry to say it—benefits only to a very small extent from what we consider the illegitimate part of the plumage business. At a liberal estimate, some seven hundred persons, including about seventy adult males, are engaged in it. The other six hundred or so are mostly young girls. At a trade demonstration organised against our Bill last year, it was possible to see that most of the demonstrators were children who had only just left school. For them, it is a blind-alley occupation, for, in the fancy feather trade, feather-weight wages are paid, and few workers care to remain in it for long. It is the opinion of the Board of Trade that in the event of our Bill passing into law, the workers would, without doubt, be absorbed in dressing poultry feathers or in the artificial flower trade. Mr. Holbrook Jackson, Editorial Director of the National Trade Press, Ltd., has even stated that passage of the Bill would probably lead to an increase in employment. The only people who stand to lose anything are those who have invested their money in what the *Daily Mail* calls "a very beastly trade." In my opinion, they have thriven too long upon it. I shall not ask you to pity them if we put them out of business. They have had long enough to get out of it. It is more than half a century since Professor Newton denounced the wearing of feathers, comparing it to the brand of Cain.

At the same time, it must be understood that though this precious industry is so useless to our country, London is its centre; London is the market where the plumage traders of the world buy their raw material. If we close London to them by our Bill, their trade is immediately disorganised, and it is highly unlikely that they will be able to build it up again elsewhere. Experience since the war has taught us that the thing destroyed in one country does not readily come to life in another. In any case, passage of the Bill means

saving the lives of all those birds that are annually destroyed for the hats of British women; but I believe it means more than that. If we refuse to tolerate the trade here, we shall make it extremely difficult for foreign buyers to obtain their usual supplies of feathers. Moreover, fashion is international. When fancy feathers cease to be worn in London, their doom will have been cried in all the other great cities of Europe. M. Krassin says that Russia has large stocks of plumes to sell to us. Let us make it quite clear to him that he can keep them as the insignia for his own Bolshevik ladies.

And now I must allude briefly to the egret farms of India, of which so much has recently been made by trade apologists, though I fail to understand what they have to do with the case. In certain parts of India, it appears, egrets are kept in pens, and their feathers are taken from them without destruction of the birds. According to the official reports I have seen on these farms, it is very doubtful whether the industry is one which should be encouraged. We have to consider how the birds in the pens have been obtained, and how they are subsequently treated. Most of these egrets —if not all—have somehow or other been snared, and a favourite method of catching them is to use decoy birds which have previously been blinded by passing a feather through their eyelids. Again, we are told that the captive egrets are plucked four times a year, and, as it is not natural for them to moult so frequently, this must involve suffering. The official report most friendly to these farming schemes states that the pain endured by the birds is comparable to the pain we should endure if we had to submit to our hair being pulled out of our heads. All this does not make us enthusiastic about egret farming, but the decision on this matter really rests with the Indian Government, and not with us at home. So long as India prohibits the export of plumage, we, in the interests of Imperial unity, ought to forbid import of plumage coming from that country. Please remember that when the trade boasts of its supplies of feathers from India, it is boasting of smuggling, and last summer we were able to run to earth a particularly bad case of smuggling in a London district, represented in Parliament by one of the little band of Members who oppose our Bill. If India decides to alter its customs regulations in favour of the produce of these farms, our attitude will not be uncompromising, for we shall then be satisfied that they are run on legitimate lines. In that case, we should only insist that the feathers imported should come, not merely from birds *kept* on farms, but from birds *bred* on farms. Our main object is to preserve bird life, and farming, unless based entirely on breeding, brings us no nearer to our goal.

For the sake of preserving good relations with India, the Dominions, and the Crown Colonies, all of which are anxious to save their birds from the plume hunters, we require an Act of Parliament to prohibit the importation of wild birds' plumage. A peculiarly despicable trick of our adversaries is to say that such an Act would cause ill feeling in France. On this point I shall content myself with quoting the opinion of M. Pierre Amédée Pichot, a member of the Société d'Acclimatation de France, who says: "I have no doubt the plumassiers will attempt to put pressure on the French Government to protest against the final adoption of the Bill by the House of Commons, but I hope the English Parliament will have its eyes open to the manœuvre. The interests of the (French) working people will not be at all affected by the suppression of the plume trade; they have many other openings for their activities, and it is only a small batch of speculators on the wholesale traffic that can suffer." In France, in fact, the position is the same as in England, and the same struggle takes place between bird-protectors and bird-exploiters. Some years ago, when M. Harancourt, of the Musée de Cluny, was addressing a meeting that had been convened in Paris to protest against the plumage trade, he was interrupted by an individual who told him that he must be a bad Frenchman to wish to ruin an important national industry. The lecturer listened patiently to the expostulation, but in the end wrung from its author a confession that he boasted of the name of Bollack, and by internationality was a German-Jewish-Pole. When one hears of "fancy feathers" being a great French or British industry, it is well to take the assertion with a full salt cellar.

Quite naturally, the trade prefers that arguments about its suppression or continuance should deal with anything but the main issue, which is, and always will

be, the preservation of birds. We live, unfortunately, in an age of extermination. For centuries man hunted bird and beast, and no great harm, perhaps, was done, but in these days, unless genuine legal protection be provided, whole species disappear. Natives of the wild lands, animated by the primitive instincts of the chase, vigilant, remorseless, untiring, knowing nothing of those restraints which from time to time stay the hand of the "sportsman," have been armed with the latest weapons of destruction. No more dangerous combination can be imagined. Extermination now can only be avoided by depriving these terrible hunters of the markets for which they work. They will still kill for food to supply their own modest needs, and sometimes, perhaps, because killing pleases them, or because some type of bird or animal seems antagonistic to their interests, but they will certainly cease from wholesale butchery as soon as they realise that it is no longer profitable. There is no time to waste, and we must not abstain from action because somebody tells us that a few farms have been started somewhere or other. Some months ago, my friend, Mr. Julian Huxley, wrote that, whilst these egret farms might some day succeed, we must first have a Bill to protect the birds from slaughter and insensate exploitation. Personally, I do not think these farms ever can be established on a sound and paying basis. "The reason is that the fashion for any one article soon ceases, and the article is then neglected sometimes for a period of ten or fifteen years." That is what Mr. Downham himself has said, and for once, I am happy to say, I find myself in agreement with him. Farms which for so long a period would not be able to sell their produce do not seem to be worth encouraging.

In a few weeks from now the Plumage Bill will again be before the House of Commons, and this time, I trust, the House will show itself tired of the obstructive tactics by which its progress was burked last session. Our majority is assured, and only obstruction can defeat us. The plumage trade will ask for more time. It has had too much time already. Whole species of birds are in danger, and, through their destruction, we human beings are in danger, too. And yet we tamely submit to the dictation of this rapacious and contemptible little trade. In conclusion, ler me read you what Mr. Ralph Hodgson has written on the subject :—

About the world, while all the world
approves,
The pimp of fashion steals,
With all the angels mourning their dead loves
Behind his bloody heels.

It may be late when Nature cries Enough!
As one day cry she will,
And man may have the wit to put her off
With shifts a season still;
But man may find the pinch importunate
And fall to blaming men—
Blind sires and breastless mothers of his fate,
It may be late and may be very late,
Too late for blaming then.

DISCUSSION.

THE CHAIRMAN (Colonel Sir Charles E. Yate, Bt., C.S.I., C.M.G., M.P.), in opening the discussion, said he was sure he should be expressing the feeling of the meeting in thanking the author for the kindly reference he had made to all the good and arduous work that Mr. and Mrs. Buckland had done for the Plumage Bill. Personally he did not support the Bill solely on the ground of the cruelty of the plumage trade. Cruelty was certainly associated with it, but it was not more cruel to shoot a bird with fine feathers than to shoot a partridge—the cruelty consisted in shooting the birds during the nesting season so that the young ones were left to perish of starvation. To his mind, however, the reason why it was absolutely necessary to get the Bill passed was that it was an imperial obligation on this country and on its Parliament to support the Parliaments and the Governments of India, of our Dominions and of our Crown Colonies, which had passed legislation prohibiting the export of the plumage of the birds which each of them severally protected. If this country allowed the plumage of birds, the export of which had been prohibited by the Governments of our Dominions and Colonies to be imported, here we were conniving at smuggling; to his mind it was an absolute obligation on the Government of this country to put a stop to such smuggling, and the people concerned should be dealt with as receivers of stolen property. As the result of the ballot, the second place on a Friday afternoon had been drawn for the Bill, and its supporters hoped to obtain the second reading of the Bill when it came on. With regard to the labour question, to which the author had referred, he thought every one would agree that if the Bill was passed the small amount of labour at present engaged in the trade would not materially suffer; the people now engaged in the plumage trade would be taken on in the

artificial flower, poultry feather, and other similar trades and no great hardship would accrue. With reference to the egret farms in India which were mentioned in the paper, he had heard from India—and he believed it to be the case—that Indians in Sind were successfully carrying on those farms; that the birds bred regularly in captivity and that the feathers taken from them were cut off at the root and not plucked. If that was really the case it rested with the Government of India to take the matter up and to modify their present laws against the export of the plumes in such a way as to allow the plumes of birds reared and bred in captivity to be brought to this country.

Lady Simon said she wished the whole audience had been composed of women, but she thought the men present must feel very complacent when they reflected that they had not to wear feathers, as the bird of paradise had, to win the women. Had women to wear plumage to win their mates? She did not think so; she believed that if they did not wear feathers they would obtain mates just as quickly, perhaps more quickly. She thought that at the root of every fashion was the idea on the part of women to outdo one another in a rivalry to catch a mate. If men did not approve of feathers, then women could really give them up. It was for women now, at the present stage of civilisation, to declare that they were not wild Indians to deck their heads with feathers. Women were supposed to be defenders of the weak and more opposed to cruelty than men were, and in the present case she thought she might say for women that very often they were not aware of the facts. One afternoon recently she was present at a drawing-room meeting held about the plumage trade and a lady came in wearing an egret in her hat, being quite unaware that it was an egret and willingly removing it when told about it. After the meeting the lady said to her that a great many women were quite ignorant about the matter, and her reply was that the women who did know ought to do their best to teach those who did not. Whenever she went into a shop and was shown a hat with an egret in it she described to the saleswomen how that egret had been obtained, and in most cases found that they knew nothing about it. Women should do their very best to make the trade unfashionable and then it would disappear. On the previous day she had seen a lady in evening dress with a large bird of paradise on each side of her head, and that appeared to be coming into fashion now. She had been in the north of Canada and had seen the Indians with feathers in their hair, and surely the women of this country did not want to borrow fashions from those people whom they regarded as uncivilised. She wanted women to join in a great crusade against the plumage trade, and those now engaged in the trade would easily find another, because a hat could be made just as pretty with ribbon and flowers as with feathers. Perhaps the men engaged in the trade did not know of the cruelty associated with it and perhaps the hunters out in the jungles who procured the feathers did not understand, but they must be taught and made to realise that the people of this country were not going to allow the trade to be carried on any longer. She had to thank the author for giving her a great deal of information in his paper, because much of what he had said was quite new to her, although she had always sympathised with those who wanted to abolish the trade. She thought it was a vulgar and brutal thing to wear such feathers; she had never done it herself and did not intend ever to do so. In conclusion, she would relate a little story bearing on the matter. A lady walking along a country lane one day saw a little boy with a nest of eggs, and said: "Oh, you naughty boy! Where is the poor mother bird, looking for those eggs?"—"In yer 'at, Ma'am!"

Mr. W. P. Pycraft, of the British Museum (Natural History), said his chief objection to the use of the plumage of wild birds in hats was that of the biologist or zoologist. Perhaps he happened to know more than most people of the importance of the birds to science, and from the economic point of view, and on that ground he looked with very grave anxiety at the continuous drain on some of the species that had been going on for very many years. He referred more especially to birds of paradise, which were not nearly so plentiful as they formerly were, and many species of which were very near extermination. He could not calmly stand by and see that going on without some sort of protest. But there was another point that had been raised and one that would probably assume considerable importance in the discussions which would shortly take place on the Bill, *i.e.*, the question of farmed egrets and moulted feathers. He had always doubted the existence of egret farms, and for that he thought the trade had only themselves to blame, because they told such weird and stupid and childish stories about them. Evidence, however, had recently come to hand that such farms did exist in Sind. Some feathers from those farms had been officially submitted to him for examination, and he had no doubt that they were the products of birds which had been bred in captivity, whose feathers could be readily distinguished by experts from those of wild birds. How far such feathers constituted the supplies furnished to the trade at the present time was a matter for consideration. At any rate, it had been demonstrated beyond doubt that egrets could be bred fairly well in captivity. Again, he thought some of the suggestions made that the depluming of

those birds was cruel could not be accepted, for the reason that if pain was caused in removing the feathers a shock was given to the system and the feathers that succeeded those removed would inevitably suffer. On an ostrich farm the feathers were cut off and the stumps removed later on, and it was done without any sort of cruelty at all, and some such plan would probably have to be adopted in the case of the Sind egrets. He thought it would be possible to have those egret farms officially registered and to take precautions to see that no feathers came into this country except under proper seal as from the farms of India, and egret feathers from other parts of the world should be barred altogether. With regard to moulted feathers, there was no doubt that such feathers could be made saleable products. He had had them submitted to him and had had them cleaned under his own supervision from directions furnished by the trade, and they certainly formed saleable products, but he was not satisfied that such feathers were the only kind of that particular species, the *herodias egretta* that came into this country, or that they came in any really large quantities. It was possible that with the moulted feathers a large number of live feathers was brought in, and until that could be shown not to be the case there would be grave difficulty in admitting moulted feathers. That was his own personal opinion, but the matter was one that would be debated and was likely to assume very considerable importance in the discussions that would take place while the Bill was before the House.

Mr. Holbrook Jackson (Editorial Director of the National Trade Press, Ltd., and a Vice-President of the Plumage Bill Group) said he agreed with all that the author had said, and the point that had pleased him most about Mr. Dewar's admirable paper was the entire absence from it of anything that could be described as sentimentalism. The author had stated his point of view with irresistible logic and in an absolutely unimpassioned way, thereby giving the lie direct to those members of the feather trade who charged the members of the Plumage Group with being sentimentalists. The author had also made clear the object of the Group, *i.e.*, the preservation of birds, which was not a sentimental object—it had its humane side and it had its scientific side, but it was not sentimental; and had also made it perfectly clear that the opposition to the Plumage Bill was mainly financial—perhaps entirely financial. By "financial" he meant something very different from industrial or commercial; he meant something concerned with the making of money as clearly and simply and obviously as money exchange; it was precisely the same thing as dealing in money. It did not refer to the employment of human beings or to the provision of useful commodities for the public; it was concerned only with the object of financial gain. That opposition was apparently very powerful, but he did not think it was powerful in bulk—either in bulk of money or in bulk of numbers. It was powerful in cupidity, for the simple reason that it was fighting for its life. Sooner or later—and he thought it would be sooner rather than later—the Plumage Bill would be passed, and the trade in wild birds' plumage was therefore doomed. He thought the propaganda of the Plumage Group was doing the members of that trade a very great service, because it was giving them ample warning of the doom that overshadowed them. The Plumage Group would be doing good service if it did nothing else but advise financiers and business men to keep away from the trade in the kind of plumage which the Bill sought to prohibit. He had been very interested in Lady Simon's remarks, and thought she made one of the best propagandist statements possible when she said it was a common and low thing to wear wild birds' plumage. It was no use arguing with some people on moral grounds, but if a woman was told that she was a common person because she wore these feathers she would go home and remove them. He thought there was no doubt that fashion was the most powerful influence known to civilised people, and it might be argued that the question of the importation of the plumage of wild birds should be dealt with by persuading the leaders of fashion to abandon the wearing of feathers, but it must be remembered that fashion was capricious and that this plumage would be sure to come into fashion again even if it went out of fashion at the present time. The only safe and sure method of dealing with the subject was by legislation. The trade had to be stopped and those interested in the subject were determined to stop it. If they were determined there was no doubt that they would ultimately win, and he thought they would win very soon. His own feeling was that it was no use appealing to women at all. George Meredith said that woman would be the last thing civilised by man, and he thought that was not far wrong. Lady Simon had said that women's instincts were kindly, and that women were always ready to defend the weak: his own feeling was that they were not only not the defenders of the weak, but not the weaker sex. They were the stronger sex, and it was no use appealing to them in the matter; they had to be forced to give up wearing feathers just as the plumassier had to be forced to give up the trade in Bird of Paradise feathers and Egret plumes.

Mr. F. Trier said Lady Astor had stated that the Plumage Bill failed to pass in the previous year because a quorum could not be obtained, and it would appear from that that

the numerous Members of Parliament who were in favour of it did not take the trouble to put in an appearance when the time came. If that was so, the same thing might happen when the Bill came forward again. He would like to ask for an explanation as to why a quorum had not been obtained.

The Chairman (Sir Charles Yate) said that on the occasion to which Mr. Trier had referred the Bill did not come before the full House, but before a Standing Committee composed of fifty or sixty Members, twenty of whom were necessary to form a quorum. Last year there was a tremendous pressure of work: Parliament sat very late and sometimes all night, and men who had to sit up all night on Parliamentary business could not always be present at Committees at 11 o'clock the next day. They had their own private businesses to attend to. Consequently on several days only eighteen or nineteen men turned up at the Committee and nothing could be done without twenty. The opponents of the Bill on the Committee stood outside the door, knowing that the Bill could not be proceeded with unless twenty members were present, but ready to come in and oppose should twenty supporters turn up. The situation had not been due to want of support on the part of the Members favourable to the Bill, but to the impossibility of their being present in sufficiently large numbers and to the obstructionist tactics of their opponents.

Mr. Gordon Jones said he was a whole-hearted supporter of the arguments the author had put forward. He quite agreed with Mr. Holbrook Jackson that the only way to succeed in the matter was by legislation. There had been nine or ten unsuccessful attempts to pass the Plumage Bill and he was convinced that the next attempt would be successful. In his opinion women did not wear feathers to captivate the male, but to annoy one another.

The Chairman, in proposing a hearty vote of thanks to the author for his very interesting paper, said he hoped it would be productive of good results and that the Plumage Bill would be passed during the present year

The resolution of thanks was carried unanimously, and the meeting then terminated.

Mr. C. F. Downham writes to challenge certain statements made by Mr. Dewar in his paper. Dealing with "moulted" or "shed" feathers of the egret collected in the heronries of Venezuela, Mr. Dewar said:—

"Very possibly some moulted plumes do reach this country, and I suspect that a special effort has been made by the London dealers to obtain a supply of them for exhibition purposes, and to place before naturalists as evidenced for the defence. Within the last few months, specimens have, I understand, been submitted to the British Museum, but I do not know when their collection began. We have been hearing of the moulted plume for the last dozen years, and, because one authentic consignment has reached the Museum authorities, there is no reason to suppose that any large number of the 'ospreys' in this season's millinery have dropped from the birds in the course of nature."

Mr. Downham writes:—

"I have handled many thousands of ounces of these shed plumes and have traced this method of collection of the feathers as far back as 1904. Such collections were confirmed by the British Minister to Venezuela in 1909 to the extent of at least 25% of the export, which, I am convinced, was, even at that date, an under-estimate.

"In reply to Mr. Dewar's direct accusation of attempting to mislead the authorities, the Plumage Committee of the London Chamber of Commerce invited the Director of the Natural History Museum and his assistants to inspect the large stocks of egret feathers from Venezuela in hand at the Port of London Authority warehouses, and in Paris, in order to confirm officially the important supply of 'moulted' and 'shed' plumes from Venezuela and elsewhere.

"The invitation was accepted."

With regard to egret farms in India, Mr. Downham thinks it would "be a work of supererogation" for him to add anything to Mr. Pycraft's remarks on this point as reported above. He claims that the plumage trade only asks to be tested by common-sense. Is it, he asks, a commercial proposition to establish a business in feathers of a bird that will pass out of existence in a few months? Is it commercial common-sense to found a business on the shifting sands of uncertain supplies?

The plumage trade, he maintains, is far more concerned than Mr. Dewar or his adherents in the preservation of those birds from which it draws its supplies of feathers. Mr. Downham continues:—"Mr. Dewar referred to the lecture of Mr. James Buckland in 1909. He quoted particularly Mr. Buckland's remarks on the Blue Bird of Paradise (*paradisornis rudolphi*)—a very rare species, not used in the trade—and also Mr. Goodfellow's statement at a conference held at the Colonial Office in 1911, that this and other rare birds of paradise were being exterminated.

"The trade subsequently showed how wrong Mr. Buckland's strictures were, and how far Mr. Goodfellow was incorrect. The Chairman of the Conference, Mr. E. S. Montagu, was constrained to say that 'in many species the trade is not responsible . . . the natives would destroy them if there were no export at all. Mr. Dewar's omission to mention

to his audience that the Dutch New Guinea Government had, since 1909, stringently regulated the hunting and trade in all wild life, and particularly in the case of birds of paradise, was truly characteristic'.

"Mr. Dewar stated that another excuse of the traders was a statement that male birds of paradise in full plumage are on the verge of senility."

Mr. Downham declares the statement was not issued by the feather trade at all, but by a Fellow of the Zoological Society, who had been acting as a collector for the Society.

Mr Dewar quoted an account of a colony of egrets destroyed in China, "the parent birds, wounded, yet still fluttering to their young with food." This good old story has served its purpose in all parts of the world, beginning with a photograph in Australia—from which country there is no export of egret plumes. It has now been revived on the authority of "a sailor"—or should it be a horse-marine ?—and is located this time in China.

Finally, Mr. Downham invites Mr. Dewar to give his authority for his opening, and widely-quoted statement that "in a single year some 35,000,000 wild birds' skins have been imported into this country." The figure, like every other "fact" adduced by the promoters of the Plumage Bill is, Mr. Downham adds, magnified at least ten times, and cannot be supported by any evidence that would be accepted by a jury.

In reply to Mr. Downham, Mr. Dewar writes as follows :—

It is particularly surprising that Mr. Downham should believe that any large proportion of the egret plumes imported from Venezuela are moulted, because, giving evidence before the House of Lords Committee of Inquiry, he stated that it was the habit of the herons to nest all over the country, and not, as is generally supposed, at special breeding grounds or *garceros*. If the birds do breed anywhere and everywhere, collection of their shed nuptial plumage must be even more difficult than is usually imagined. The British Minister at Caracas has said that he has "no manner of doubt that the vast majority of the egret plumes exported to Europe are obtained by the slaughter of the birds during or about the breeding season."

I am not, however, surprised to hear that there are stocks of moulted feathers at the Cutler Street warehouse. Such feathers, being of little use for millinery, would, of course, accumulate there.

In regard to "farms" in India, I have nothing fresh to add. The matter ought to be left to the decision of the Indian Government. As to the fancy feathers business being "a commercial proposition," I hold it to be as unsound commercially as in other ways. Also, I continue to have more confidence in the disinterested investigations of Mr. Buckland and Mr. Goodfellow, than in denials made in order to give the trade a few more years of life.

I did not mention hunting regulations in Dutch New Guinea, because, as various passages in my paper show, I have no faith in these regulations made for uncivilised countries. As a rule, they are good for nothing except to screen the traders. Mr. Downham forgets to say that, according to his evidence before the House of Lords, the Dutch Government once offered to sell to one firm the whole of its New Guinea shooting rights.

The curious statement about the senility of the fully plumaged birds of paradise was, I am aware, advanced by a Fellow of the Zoological Society. It has been used in defence of the feather trade, and I wished to expose its absurdity.

I do not know why Mr. Downham should be surprised because similar accounts of the slaughter of the egret come from Australia and China. They come with horrible monotony from every country where the egret is found. There is, certainly, no export of plumes from Australia now—or it is very small. The Australian Government can, and does, protect its birds.

My figures for the import of wild birds' skins were, probably, a rather conservative estimate. M. Paul Sarasin, at the Eighth International Congress of Zoologists, estimated that fashion killed from two to three hundred million birds every year. His figures, and mine, however, date from before the war, and since reading my paper, I have received evidence showing that recent plumage imports to this country are considerably smaller than in the past. Perhaps, there are no longer the birds to kill ; perhaps our crusade has not been without effect on women's minds. In any case, the time has come when the trade in fancy feathers, having sunk to a low ebb, can be conveniently and painlessly extinguished.

PRODUCTION OF CACAO IN TABASCO.

The cacao of the State of Tabasco (Mexico), though one of the richest in flavour and nourishing qualities of all varieties in the world's market, is probably the least known. This is due partly to its restricted area of cultivation, but chiefly to its remarkably high price in comparison with the South American and East Indian product. The city of Villahermosa, the capital of Tabasco, is the centre of production and the only market for the cacao beans in Mexico. From this city the product is shipped to Mexico City and Merida, Yucatan, exclusively, there being no shipments abroad.

The production of cacao in Tobasco for 1920 is estimated at 3,300,000 lbs., the largest crop since 1913. The price per kilo (2.2lb.) has

varied in the local market during the year from 70 cents U.S. currency in November to twice that figure in April and May, this high quotation being due to political disturbances. Normally, the market price remains about 1 dol. 25 cents. (U.S.) per kilo throughout the year.

Mexican cacao, besides being of superior quality, is also far less bitter than other varieties. For this reason, writes the U.S. Consul at Frontera, it requires less sugar in the manufacture of choclates and bonbons and, accordingly, does not permit the substitution of sugar in the manufacture of candies. On the other hand, as Tabasco cacao is richer in fats and oils, it should be profitable for manufacturers to import it for the manufacture of cocoa and chocolate as beverages, or even as foods, since less cacao and sugar will be required per unit quantity.

The native tree differs very little from other varieties. The beans are inclosed in a sort of shell, the mazorca, which must be crushed for their extraction. The fleshy pulp surrounding the seeds in the mazorca must be washed out or separated from the beans, a process which entails the chief expense in the operation of harvesting the cacao. The beans are then dried in the sun, ovens not being in use. Only manual labour is employed in the cleaning process. If a suitable machine for this work were introduced, thereby cheapening the process of extracting and drying the beans, it is possible that the export price could be reduced to the point where the product would be within the reach of foreign buyers.

VANILLA PRODUCTION IN MEXICO.

At present Mexico employs over 50,000 people in the cultivation and extraction of vanilla—one of the most important of the minor extractive industries of that country. Vanilla is indigenous to the soil of Mexico. It is principally cultivated in the districts of Papantla and Misantla in the State of Vera Cruz, the most productive region lying southeast of Tuxpan, between the Rivers Nautla and Tuxpan.

From a report by the U.S. Trade Commissioner in Mexico it appears that vanilla grows more or less in a wild state in the low hills, and with such abundance that it perfumes the air in the vicinity. Formerly this wild vanilla was considered common property. A French colony established on the banks of the Nautla River, which engaged in the cultivation of vanilla on a large scale, met with very satisfactory results. The vanilla grows best in rich, sandy soil not drained too thoroughly. When growing wild it is usually sheltered by the trees of the forest, and in the state of cultivation it is protected by trees planted for that purpose. The temperature most favourable for its production is about 85° F. It grows best at an altitude of 1,000 feet above sea level. The character of the soil, the temperature, humidity, etc., influence the quality of the vanilla, its aroma, and its strength.

There are different varieties of vanilla in the vicinity of Misantla, known as the Misantla beans, which have a coarse bark. They are not so plentiful nor are they considered so good as the Papantla bean. These indigenous varieties are the cimarrór, the mestiza, and the mansa. When they are cured only an expert can distinguish between the various classes. There is also a wild bean known as the vanilla platano, which the Indians eat. This differs from the ordinary vanilla above described (planifolia) in that the plant is much smaller but has larger leaves.

Vanilla ripens most extensively in January and February. However, there is so much demand for the fruit that for many years crops have been prematurely harvested in October and November. As a result the beans weigh a pound less per thousand than they would normally. In compliance with an order of the Government, the authorities were formerly instructed to prevent the harvesting of unripe fruit, but this order has not been enforced. A great deal of that which is produced early is stolen by natives, who realise that they can place the product on the market to good advantage. Many planters have their domiciles and headquarters at a considerable distance from their plantations, and in order to avoid the plundering of their crops they cut the vanilla early rather than be deprived entirely of the fruit. One of the great problems of the owners of vanilla plantations is to provide against the robbery of their crops.

For commercial purposes vanilla is divided into four classes: The large-fine, the small-fine, la zacate, and la basura. The large-fine and small-fine are practically of the same commercial value. The former weighs from 10 to 12 ounces, and each bean is about 20 centimetres long; the latter is from 10 to 15 centimetres and its weight is almost equal to the large-fine. The zacate, which is a large vanilla bean weighing more than the former two, grows more abundantly along the roadsides in the warm and hot regions of Mexico, where formerly its fruit was considered to be without commercial value.

Practically all of the exports go to the United States, for which reason the American dollar is the basis of price, both for buying and selling.

THE CONDITIONING OF SILK.

The process of conditioning silk, carried on by the so-called conditioning houses, consists in fixing the normal amount of moisture in vegetable or animal textile fibres in their natural state, determining in this way the legal market weight of such fibres. Individual

concerns or persons possess no means by which they might standardise weights, and this operation is carried on under strict Government supervision. Recourse to the operations of the conditioning house is not obligatory, but few contracts are made that do not pass under its control.

Prior to 1800 the Lyons Conditioning House was a private concern, but by decree passed in 1805 it became part of the public administration of the Lyons Chamber of Commerce, and it has since served as a model for all such establishments created in France or in other countries. At the beginning of its career the amount of silk conditioned was only some 40,000 kilos, or about 88,000 pounds, whereas in 1913 the figure reached 8,414,341 kilos, or over 18,000,000 pounds.

Besides weighing and conditioning the silk, or, in other words, introducing the proper amount of water into it, the Lyons Conditioning House, by a system of degumming, determines the amount of gum and other foreign matter in the silk. The silk filament as secreted by the silkworm is composed of two parts: (*a*) the solid brilliant white interior, the silk proper, called the "fibroin," and (*b*) an exterior envelope which covers this fibroin. This envelope or coating is yellow or white, according to the origin of the silk. White silks contain less of the coating than yellow silks. The operation of removing this coating from the silk is called *decreusage* or degumming.

The work of degumming is done by simply washing the silk thoroughly in a hot bath with soap. It is sometimes found that certain silks wind better if vaseline or kindred products are added to this bath. Careful tests have made it possible to determine exactly how much of such products may safely be introduced. By chemical analysis the conditioning house isolates all foreign matter, soluble and insoluble, in the silk. Finally, by a series of special tests, the thickness of the threads is determined.

According to a report by the U.S. Consul at Lyons, the method universally followed in conditioning textiles, silk, wool or cotton, is that established by the Lyons Conditioning House. The textile is first reduced to a state of absolute dryness, and then the necessary proportion of water is added to it, this amount varying according to the textile. For silk the conventional coefficient is 11 per cent. For wool it is 8¼ per cent., and for cotton 8½ per cent. To determine the weight of a lot of silk in its dry state specimens are taken from all parts of the lot before it is subjected to the drying process. These specimens are weighed and then dried and weighed again, and this comparison forms a basis for fixing the dry weight of the entire lot. The "conditioning" weight is then obtained by adding the necessary coefficient of water. The silk is very rapidly dried in ovens at a temperature of 140° C. Ventilation is provided and the whole operation takes only 15 minutes, at the end of which time the 11 per cent. of water is added. Wool and cotton are dried at a temperature of 110°.

The thickness or size of silk is classified by weighing a specified length.

GENERAL NOTES

MACHINE FOR RAISED EMBROIDERY.—The United States Consul at Lyons reports the invention of a machine at that place for the making of raised embroidery in gold and silver. It is stated that the stitch is a copy of an ancient form of embroidery and gives an impression of handwork, and is also the first machine that has been successful in using the metallic thread. Various machines have been employed in the making of raised embroidery in other threads. It is stated that the machine is the result of seven years of study, and that the results are very satisfactory.

BEE INDUSTRY IN SPAIN.—It is calculated that Spain has approximately 1,600,000 beehives, nearly all of which are found in the Valencia, Aragon, Valladolid, Guadalajara, and Majorca districts. The annual production of honey, according to a report from the U.S. Consulate-General at Barcelona, amounts to about 19,000,000 kilos (1 kilo = 2.2 pounds), which, at the price of 2.50 pesetas per kilo, represents a value of 47,500,000 pesetas (1 peseta = 9⅗d. at par value). To this figure there must be added the value of the beeswax. Under normal conditions some 60,000,000 pesetas' worth of honey and wax are yearly produced in Spain.

VICTORIA AND ALBERT MUSEUM.—The Franco-British Exhibition of Textiles will remain open until Sunday, the 17th inst., inclusive. Since the time of its opening, the Exhibition has been visited by nearly 300,000 people.

MEETINGS OF THE SOCIETY

ORDINARY MEETINGS.

Wednesday evenings, at 8 p.m.:—

APRIL 20.—SIR JAMES CANTLIE, K.B.E., LL.D., F.R.C.S., (1) "Thomson's Apparatus for Armless Men. (2) X-Ray Motor Ambulance Service for the United Kingdom." (A demonstration of the Armless Machine will be given.) THE HON. SIR ARTHUR STANLEY, G.B.E., C.B., M.V.O., in the Chair.

APRIL 27.—SIR JAMES P. HINCHLIFFE, "Research in the Wool Industry."

MAY 4.—SIR GEOFFREY G. BUTLER, K.B.E., Director, British Bureau of Information, U.S.A., 1917-19, "American Recollections."

MAY 25.—DR. C. M. WILSON, "The War and Industrial Peace: an Analysis of Industrial Unrest."

MONDAY, MAY 30.—SIR KENNETH WELDON GOADBY, K.B.E., Medical Referee for Industrial Poisoning, County of London, "Immunity and Industrial Disease."

INDIAN SECTION.

At 4.30 p.m.

FRIDAY, APRIL 22.—LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O., "The Common Service of the British and Indian Peoples to the World." (Sir George Birdwood Memorial Lecture). THE EARL OF LYTTON, Under-Secretary of State for India, in the Chair.

TUESDAY, MAY 3.—WILLIAM RAITT, F.C S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India." SIR ROBERT W. CARLYLE, K.C.S.I., C.I.E., late Member of the Government of India, in the Chair.

FRIDAY, JUNE 10.—SIR GEORGE SEYMOUR CURTIS, K.C.S.I., Member of the Executive Council, Bombay, "The Development of Bombay."

INDIAN AND COLONIAL SECTIONS.

(Joint Meeting.)

At 4.30 p.m.

FRIDAY, MAY 27.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

CANTOR LECTURES

Monday evenings at 8 o'clock.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures.

Syllabus.

LECTURE II.—APRIL 18.—X-ray Spectra. Spectrophotometers, especially Sector-spectrophotometers for exploring the Ultra-violet region. Absorption spectra by old and new methods.

LECTURE III.—APRIL 25.—The significance of Absorption spectra. Studies on the Ultraviolet absorption spectra of Blood Sera, Uric Acid, Cellulose Films, etc. Applications of Spectroscopic Instruments to the technological study of Fluorescence in Paper, Textiles and other materials.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, APRIL 18.. Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev. Canon J. T. Parfit, "Religion in Mesopotamia and its Relation to the Prospects of Eastern Christendom."

Surveyors' Institution, 12, Great George Street, S.W., 7 p.m. (Junior Meeting.) Mr. J. R. Toovey, "Tithe Rent Charge."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. A. E. Munby, "The Utility of Research on Building Materials."

TUESDAY, APRIL 19.. Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. A. W. Dayson, "Education and Training of a Driller."

Statistical Society, 9, Adelphi Terrace, W.C., 5.15 p.m.

Transport, Institute of, at the Institution of Civil Engineers, Great George Street, S.W., 5.30 p.m. Mr. A. Watson, "Some Advantages of Control as applied to Traffic on Railways."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. A. Keith "Darwin's Theory of Man's Origin (in the light of present-day evidence)." (Lecture I.)

Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Mr. S. H. Warren, "Report on Excavations at the Stone Axe Factory of Graiglwyd in 1920."

Zoological Society, Regent's Park, N.W., 5.30 p.m. (1) The Secretary, "Report on the Additions to the Society's Menagerie during the month of March, 1921." (2) Mrs. J. Longstaff, "Observations on the Habits of the Snail, *Cochlitoma zebra*, var. *fulgurata*, and *Cochlitoma zebra*, var. *obesa* Pfeiffer, in Confinement." (3) Mr. R. I. Pocock, "On the External Characters and Classification of the Procyonidæ (Raccoons, etc.)." (4) Mr. M. A. Smith, "New or Little-known Reptiles and Batrachians from Southern Annam (Indo China)."

WEDNESDAY, APRIL 20 .. Meteorological Society, 70, Victoria Street, S.W., 5 p.m.

Geological Society, Burlington House, W., 5.30 p.m. (1) Mr. J. A. Douglas, "Geological Sections through the Andes of Peru and Bolivia: III.—From Callao to the River Perene." (2) Prof. O. T. Jones, "The Valentian Series."

THURSDAY, APRIL 22 .. African Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi W.C., 5 p.m.

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace Road, S.W., 6 p.m. Dr. J. E. Borland, "The Musical Training of Children."

Metals, Institution of (London Section), at the Sir John Cass Institute, Jewry Street, Aldgate, E.C., 8 p.m. Dr. W. R. Ormandy, "Refractories."

Royal Institution, Albemarle Street, W., 3 p.m. Mr. H. S. Foxwell, "Nationalisation and Bureaucracy." (Lecture I.)

Numismatic Society, 22, Russell Square, W.C. 6 p.m.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m.

FRIDAY, APRIL 22.. Sociological Society and South-Eastern Union of Scientific Societies and the Regional Association (Joint Meeting), at the Linnean Society, Burlington House, W., 6 p.m. Mr. G. Morris, "The Saffron Walden Survey."

Technical Inspection Association, at the Society of Arts, John Street, Adelphi, W.C., 7.30 p.m.

Royal Institution, Albemarle Street, W., 9 p.m. Sir James Walker, "Electro-Synthesis in Organic Chemistry."

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Sir Richard Glazebrook, "Limit Gauging."

SATURDAY, APRIL 23.. Royal Institution, Albemarle Street, W., 3 p.m. Mr. H. Y. Oldham, "The Great Epoch of Exploration." (Lecture I., Portugal.)

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES

NEXT WEEK.

MONDAY, APRIL 25th, at 8 p.m. (Cantor Lecture). SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." (Lecture III.)

WEDNESDAY, APRIL 27th, at 8 p.m. (Ordinary Meeting.) SIR JAMES P. HINCHLIFFE, Chairman of the British Research Association for the Woollen and Worsted Industries, "Research in the Wool Industry." SIR THOMAS H. MIDDLETON, K.B.E., C.B., LL.D., Member of the Development Commission, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

SEVENTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 13th, 1921; SIR ARTHUR DUCKHAM, K.B.E., M.Inst.C.E., in the chair.

The following candidates were balloted for and duly elected Fellows of the Society:—

Hayes-Gratze, E. V., London.
Jennings, Mark, Bury St. Edmunds.
Simpson, Hon. Hubert Ashton Laselve, O.B.E., J.P., Kingston, Jamaica.

A paper on "Low Temperature Carbonisation and Smokeless Fuel" was read by PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

CANTOR LECTURE.

On Monday evening, April 18th, MR. SAMUEL JUDD LEWIS, Ph.D., D.Sc., F.I.C., Lecturer in Spectroscopy, University College, London, delivered his second lecture of his course on "Recent Applications of the Spectroscope and Spectrophotometer to Science and Industry."

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

FIFTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 16TH, 1921.

THE RIGHT HON. LORD JUSTICE ATKIN, in the Chair.

The paper read was:—

SCIENCE AND THE INVESTIGATION OF CRIME.

By C. AINSWORTH MITCHELL, M.A., F.I.C.

It is obvious that the title of the paper which your Council asked me to read before you is so comprehensive that it would not be possible within the limits of a single evening to deal adequately with all parts of the subject, and I therefore propose to give a descriptive survey of many portions of it and to deal more fully with some of those branches of scientific investigation upon which I can speak from personal experience.

In spite of having to contend with all the resources of science and art at the disposal of the authorities, the natural astuteness of the criminal mind not infrequently proves a more effective weapon, and yet, if we compare the conditions of to-day with those of a hundred years ago, it will be seen that each fresh practical application of scientific discovery has reduced the chances of an evil-doer escaping

justice. At the beginning of last century everyone who committed a secret crime had probably an even chance of evading capture if not detection. The means of communication were slow and uncertain, and there were no facilities for the rapid distribution of news to distant places. Such a romantic episode as the ride of Margaret Catchpole from Ipswich to London would hardly be possible to-day. It is a point of some interest that the value of scientific methods of communication should have been dramatically brought home to the public mind by their application to the capture of criminals. In 1843 a brutal murder was committed at Slough by a man named Tawell, who, having managed to catch the train to London before suspicion was directed to him, anticipated that he would be able to escape detection; but the telegraph had recently been installed on the Great Western Railway, and when Tawell reached Paddington he was met by detectives who had been warned while the train was on its way.

Still more striking was the situation when Crippen and his companion attempted to escape to Canada on the S.S. "Montrose." Owing to the use of wireless telegraphy, the only people in the civilised world who were not aware that the wanted couple were on board were the other passengers on the steamship. Advertisements in the press, reproduction of the portraits in the daily newspapers and on placards in every populous centre, the telephone, and wireless photography have all increased the difficulty of wanted persons escaping detection.

When it comes to the question of identification, however, the problem is perhaps less simple. The world contains some 1,600 millions of people, and notwithstanding the infinite variety of human features, it may be regarded that there is hardly any one alive to-day who could not be taken for somebody else, even when the two faces and forms were somewhat critically compared, whilst on the uncritical generalisation of a hasty glance, numerous people might be mistaken for any given individual.

Mistakes of identification have probably been a more fruitful source of miscarriage of justice than all the other causes put together. Every work on the laws of evidence cites notorious instances of the kind to prove how liable to error the direct evidence of eye witnesses may be. In a criminal trial in the early years of last century, the judge referred to a case where a woman accused of child-stealing had been identified by eleven witnesses and was convicted. Subsequently it was discovered that a mistake had been made, and another woman was identified with equal certainty by no fewer than thirteen witnesses. "These contradictions," commented the judge, "make one tremble at the consequences of relying on evidence of this nature unsupported by other proof."

It would not be difficult to compile a long list of similar victims of mistaken identification, many of whom have received a "free pardon" for an offence which they never committed, whilst in other cases the error has been discovered too late. The Beck case, where a man was wrongly identified by a large number of witnesses on two separate occasions, is too well known for comment; whilst a still more recent case is that of Thompson, who, in 1912, was twice convicted and sentenced on the evidence of twenty-two witnesses, all of whom were subsequently proved to have been mistaken.

If the observations of eye-witnesses under the most favourable conditions be thus liable to be mistaken, the chances of error are enormously increased when the identification has been based upon a momentary glimpse in defective light, such as a gun-flash, or upon a single trait, such as a characteristic gait, and such evidence is essentially only of a corroborative nature.

The invention of photography placed a new weapon in the hands of the Police Authorities for establishing the identity of a "wanted" person. In many cases it has led to the detection of a criminal, but on the other hand, is not proof against efficient disguise. Moreover, since a photograph represents only one aspect, and that often a false one, of a person at a particular moment, there is often a chance of its being mistaken for that of someone else. There have, in fact, been numerous instances of mistaken identification from photographs, one of the most remarkable of which is that of the two Will Wests to which I refer below.

Notwithstanding the glaring errors that were proved to have resulted from the identification of criminals from old photographs, the system was vigorously defended in Parliament in 1887 and 1888 by the then Home Secretaty, and it was not until 1894 that any further advance was made.

In that year a Special Committee recommended that the French anthropometric system of Bertillon, which is based upon a record of specified bodily measurements and characteristics, was the most suitable for preliminary classification, but that for detailed grouping the finger print method gave the best results. A combination of the two methods was, therefore, adopted and continued in use until 1901, when it was replaced by finger print identification.

No greater proof of the superiority of this system over both the Bertillon and the photographic methods can be found than in the cases of the two Will Wests, which I have the permission of Professor Wilder and Mr. Wentworth to bring before you to-night. In 1903 one of these men, a negro, was committed to the Leavenworth Penitentiary, Kansas, U.S.A., and a few days later was photographed and his measurements taken. The Clerk, thinking that he remembered the face, remarked that he had been there before. This the man denied, but the Clerk, still unconvinced, compared the measurements which he had just made with his record file and produced a card with an accompanying photograph. The prisoner stared in amazement, admitted that it was his portrait, but still protested that he had never been there before. The clerk then read the details from the back, from which it appeared that the original of the photograph was at that very moment a prisoner in this penitentiary, serving a life sentence for a murder committed in 1901.

It was thus found that there were two Will Wests under the roof of the same prison, each of whom showed practically the same Bertillon measurements, and had faces so similar that it was almost impossible to distinguish the two men apart.

This unique series of coincidences affords convincing evidence that the scientific measurements of the human frame cannot be accepted as absolute proof of identity, even when they corroborate the evidence of an eye-witness or of the camera.

The same remark applies to the identification of a person from fragmentary remains of the body, although under certain conditions the expert evidence drawn from such a source may be of the highest value in confirmation of other evidence also incomplete in itself.

In the notorious Crippen case, human remains were discovered, but it was not possible to identify them absolutely as having formed part of the missing woman. Evidence was given, however, that marks upon a fragment of skin were due to a scar from an operation, and although this was at first disputed by medical witnesses for the defence, these witnesses finally admitted that the conclusion was correct. It was also proved that the wife of the prisoner had undergone an operation which would have produced such a scar, and this, in conjunction with the other medical evidence, greatly increased the degree of probability that the remains were those of the supposed victim.

To the same class of evidence belongs the expert conclusions of dentists, whose work makes them familiar with the distinctive characteristics of a number of people. Such evidence was regarded as conclusive in the trial of Professor Webster in 1849, for the murder of Dr. Parkman, whose body was cremated in a laboratory furnace with the exception of a block of teeth which was identified by the dentist of the victim. By a strange coincidence a murder was brought home to another Dr. Webster in 1912, the victim being identified by a gold tooth which the prisoner had overlooked.

Evidence of identity has also been obtained from the coincidence between the nails in a boot, and the marks of a footprint from the boot. But obviously such cases some one else might have been wearing the boot. Had the imprints been those of a naked foot, it might have been possible to establish the identity of a suspect. When Jezebel was thrown to the dogs and they went to bury her, they found no more of her than the skull and the feet and the palms of her hand, so that no man could say "This is Jezebel." But as Sir Francis Galton remarked, it was by the soles of the feet and the palms of the hands, and by them alone, that it would have been possible to identify the body of Jezebel with absolute certainty.

So much has been written upon the subject of identification of individuals by the patterns formed by the ridges upon the finger, and their comparison with accidental imprints, that it is not necessary for me to describe the principles of the system. Those who are interested in the subject will find the methods of classification and mechanical development fully dealt with

in Sir Edward Henry's little handbook "*Classification and Uses of Finger Prints.*"

There are, however, numerous new developments and extensions of the system which are of great interest. As showing the superiority of the method over all other methods, it is interesting to note that the finger prints of the two Will Wests are quite distinct.

Additional evidence has also been gained of the persistence and the permanency of the characteristics of the papillary ridges upon the finger of an individual.

The prints shown upon the screen were sent to me by Sir William Herschel. The first was made in 1861 and the second in 1916, not long before his death. It will be many years before this record of the persistence of the characteristics of a pattern for so many years can be beaten.

It is to Sir William Herschel that we owe the first practical introduction of the use of finger prints, but it was Dr. Faulds who many years later made systematic experiments upon the development of accidental finger prints and their use in the detection of criminals. It was a strange coincidence that two Englishmen in Asia should have been studying the method from different points of view, unknown to each other, and the history of Darwin and Russel Wallace was thus repeated. In this case, however, Faulds had the misfortune to find on publishing his work that his main idea had been anticipated.

The persistence of the patterns on the fingers has recently been shown by an interesting series of imprints made by Mr. Wilder, showing the effect of a burn, and the gradual restoration of the pattern with the recovery of the skin.

The branch of the subject to which I have given the principal study has been the chemical development of latent prints upon paper. Forgeot many years ago described a method of developing latent finger prints upon paper such as the leaves of a book, his method being based upon the fact that there is normally a slight secretion of oil upon the fingers, and that in the impressions produced by them some oil will be conveyed to the paper. Hence, when the paper is subsequently treated with a suitable ink, the ridge marking will repel the liquid, whereas the intermediate furrows and the rest of the paper will be stained. In this way I have developed practically invisible finger prints after periods up to three years. One shown on the screen was developed with ordinary "Swan" ink after more than three years.

The objection to methods in which liquid reagents are used is that it is not always easy to apply the right quantity. When applicable, it is much more satisfactory to use a reagent in the form of vapour. Iodine vapour gives very good results, whilst for fairly recent finger prints osmium tetroxide (the osmic acid of the microscopists) frequently gives very delicate prints. The method is not applicable, however, after a long period, but when it can be used it is particularly suitable for studying the position of the pores upon the papillary ridges.

This development of the finger print system is due to Dr. Locard, the Director of the Police Laboratory at Lyons, and I have to thank him for allowing me to bring some of his results before you to-night. As you are probably aware, the patterns on the ridges of the skin are composed of a series of pore units which unite to form the lines. Now, these pores differ in size, shape and position on the ridges in the case of different individuals, and are as persistent as the patterns in the same individual; they are, therefore, as decisive a proof of identity as the entire finger prints. Moreover, it enables an accidental print to be identified from other parts of the hand, and in such cases, instead of there being only one or two points of resemblance, there may be hundreds of points of coincidence.

One of the most striking instances of the value of this new method of poroscopy was shown in the case of Boudet and Simonin. A burglary was committed in Lyons, and several pieces of jewellery were stolen. There was no clue to the thieves, but the lid of a rosewood box was covered with blurred finger prints. These were developed with lead carbonate and photographed, and some then found to coincide with finger prints of a man named Boudet who was known to work with a companion Simonin. The imprints of the palms of both these men were then taken, and the pores studied. In the case of Boudet there were correspondences in 901 pores, whilst the palm of Simonin showed over 2,000 such points of agreement. These similarities were demonstrated in court by means of enlarged photographs, and on this evidence alone the jury convicted

both Boudet and Simonin. The reproduction of these remarkable prints, shown upon the screen, were sent to me by Dr. Locard, to whom I am indebted for permission to show them here.

Another notable development of the system of identification by means of the ridge patterns of the skin has been the classification and study of the markings upon the soles of the feet. In European countries, the method is hardly likely to be of much use for the identification of accidental footprints, but in hot countries, where it is the custom to go barefoot, it is quite probable that the results so far obtained may find a practical application in the detection of crime.

Messrs. Wilder and Wentworth have published the results of their investigations on this and kindred subjects on the identification of human beings, in their most interesting work upon the subject, "Human Identification," and they have very kindly allowed me to show you some of their results to-night.

The soles of the feet are covered with ridges analogous to those upon the palms of the hand, whilst distinctive patterns are found upon the toes and at the base of the toes. Usually the rest of the sole is crossed by transverse lines which extend upwards beyond the sole, and only in very exceptional cases is a definite pattern found upon the heel.

So far, such calcar patterns are known to have been observed only in eight or nine cases, although that number would probably be considerably increased if a systematic search were made. Still, the possessor of a pattern upon the heel is, as Messrs. Wilder and Wentworth observe, a marked man. The two examples of such heel patterns shown upon the screen were photographed directly from the actual imprints which they sent to me—one being that of a man and the other of a woman.

The classification of sole prints presents many more difficulties than that of finger prints, and Messrs. Wilder and Wentworth have very wisely based their system upon the broad details of the patterns in the tread area at the base of the toes—that is to say, the ball area at the base of the great toe and the three plantar areas.

This method seems to be based on a fairly comprehensive scheme, and should prove invaluable for classifying and indexing sole prints. It is interesting to note that the use of sole prints as a means of identification of infants has for some time been in use in the Chicago Lying-in Hospital.

Those who wish to study this subject further may be referred to the original work of Wilder and Wentworth, which I have already mentioned. Incidentally this book shows the advantages to be gained by the collaboration of a scientific man, such as a Professor of physiology, and a trained Police officer.

Although the identification of a suspected individual is one of the most important links in a chain of evidence, it is frequently insufficient to connect him with the crime, and it is at this stage that scientific investigation and interpretation of collateral facts become necessary.

At one time, all such evidence devolved upon the medical man, who represented the best scientific opinion available. And so we find in the records of old trials that doctors were called to give evidence upon subjects such as witchcraft and the spontaneous combustion of human beings, in addition to questions which are now regarded as exclusively within the province of the chemist.

In the case of toxicology, for instance, it is interesting to follow the gradual evolution of the chemical side of the evidence. The first case in which decisive scientific evidence of poisoning is recorded is that of Mary Blandy, in 1752, where the doctor who examined the powder handed to him showed that it agreed in its characteristics with white arsenic.

With the advance in chemical knowledge, more delicate tests were applied, and the chemical results were considered in conjunction with the medical symptoms and post-mortem appearances, but even at the middle of the last century toxicology was still in its infancy, and mistakes were not infrequently made.

In the notorious Palmer case, for instance, Palmer, who was a medical man, attempted to escape conviction by mixing his poisons. One was detected, whilst the other, strychnine, was not found, although the medical symptoms pointed to that poison. Taylor, the Official Analyst to the Home Office, was publicly accused of incompetence, and so acrimonious was the evidence of the scientific witnesses for the defence, that the judge remarked that it was essential to the ends of justice that a witness should not become an advocate.

A year or so later, another medical man, named Smethurst, who was tried for poisoning a woman with arsenic, saved his life by setting a trap for the Official Analyst, into which the latter fell. At that time the recognised test for arsenic consisted in separating it upon a strip of copper. Now it subsequently transpired that Smethurst was well aware that certain salt solutions will dissolve copper, and that copper frequently contains arsenic as an impurity. He, therefore, placed a bottle of such a solution among the other drugs to be examined, and Taylor reported that this solution contained arsenic. Subsequently, he frankly admitted that this arsenic had been derived from the copper itself, and although Smethurst was convicted, the doubt thus raised led ultimately to his being pardoned.

At the present day it is well known that every precaution must be taken to guard against impurities in the reagents, and the tests for arsenic are so refined that less than one part per million can be estimated. It is not the accuracy of the methods that are now challenged, but the calculations of the total quantity of arsenic in the body, based upon the results of such methods applied to certain portions.

In like manner, the scientific examination of blood stains has evolved from evidence that the stain is like that produced by blood, into the refined methods of biochemistry, by means of which it is possible to state not only that a stain consists of blood, but also that it is in all probability human blood or the blood of a definite animal, as the case may be. Without going into technicalities it may be mentioned that the principle of the method is to inoculate an animal with the serum of the blood of another animal, such as a horse. Subsequently, when that animal is killed, its serum will give a precipitate when treated with the serum of horse blood, but not with the serum of the blood of another animal. There are, of course, numerous precautions to be taken, and the test has the drawback that the blood of allied species of animals gives similar reactions, and in this connection it is interesting to note that the blood of anthropoid apes will give a reaction with a serum which has been made specific for human blood and *vice versa*.

Another question which is frequently of great importance in criminal investigations, is the distinction of human hair from the hairs of different animals. Although this may eventually be decided by biochemical methods, the problem is at present solved by the use of the microscope. In the popular view, wool and hair are usually regarded as quite distinct, but the difference is one of degree rather than of kind. Wool may be defined as a particular variety of hair of fine texture, characterised by having a more or less curled form and a surface covered with scales. As a rule there is no central canal (medulla). This distinction is by no means sharp, and the two types of hair may be found on the same animal. For example, in the hair of the goat there is a lower layer of woolly fibres, and the same thing may be observed in the coats of certain breeds of dogs, such as the Bedlington terrier. The ordinary domestic sheep, when allowed to run wild, will, in the course of a generation or so, produce a fleece containing a large proportion of straight fibres.

Important factors in distinguishing between different kinds of hair are the character of the scaling upon the woolly fibres, the markings on the *cortex* or surface below the scales, the presence or absence of a *medulla*, and, if present, its form. For example, the scales on merino wool go round the fibre, so that the microscopic appearance suggests a Malacca cane: whilst in cross-bred sheep the scales are smaller and cover only a small surface of the axis. The scales of the fine hairs of fox fur usually project beyond the edges and have the medulla as a cellular structure so that the fibres resemble a jointed chain. The hairs of the cat, dog, bear, kangaroo, rabbit, and so on, may be readily distinguished by their characteristics, but allied species, such as the dog and wolf, and cat and leopard, show numerous points of resemblance. These resemblances suggested to me the possiblity that man's nearest relations among the animals might also show analogous resemblances to human hair, and this was found to be the case.

The hair of a new-born infant closely resembles that of the merino sheep, and in that of a young child the scales are very scanty, whilst in adult human hair they become more numerous and more compressed. There is also a tendency towards a jointed structure, which disappears in the hair of the adult.

In the hair of the young chimpanzee

Some of the fibres resemble the hair of a young child, though the scaling is less pronounced, but in others there is a distinct medulla. In the old chimpanzee some of the fibres near the base also resemble adult human hair, but with less pronounced scaling, whilst a medulla interrupted in places will be found in others. The hair of the orang-outang has also many points of agreement with human hair.

Speaking generally, it may be said that a medulla is more common in the hair of the higher apes than in European hair, but I have found that the hair of the negro shows a close relationship to that of the anthropoid apes.

It also seemed probable that since axillary hair is probably a vestige of man's former ancestry, a medulla would be found in such hair. This was confirmed by a study of hair from the human armpit, some fibres of which showed a narrow irregular medulla with dots of pigment, whilst others again showed no signs of a medulla, but were covered with fine scaling, which was well marked towards the base.

From these results the general conclusion may be drawn that whilst human hair may be readily distinguished from the hair of all the common domestic animals, there might probably be some difficulty in distinguishing it from the hair of the higher apes.

I am indebted to Mr. R. M. Prideaux for the microscopical drawings of hairs shown upon the screen. For such work *camera lucida* drawings give a much better representation of the fibres than photomicrographs.

The problem of distinguishing hair from the ordinary textile fibres, such as silk, cotton, linen, jute and hemp is usually quite a simple matter, for each has its own characteristic structure. It may often be of considerable importance in criminal work for proving the identity of two fabrics, as in a case cited by Mr. Lucas in his *Legal Chemistry*.

The microscope is also indispensable for ascertaining the nature of fibres which compose the paper of a document. Old writing paper usually consists of linen which has been more or less distorted in the process of manufacture. At a later period paper containing cotton fibres made its appearance, and these fibres may be recognised by their characteristic twist, whilst later still a wood pulp was introduced as a paper material. It is obvious that a document alleged to be, say, fifty years of age written upon paper having a characteristic structure of Manilla paper could hardly be genuine.

Apart from the structure of the paper itself, there are pronounced differences in the nature and quantities of the mineral constituents in modern kinds of paper, and I have also found it possible to distinguish between a forged and a genuine document by a chemical examination of the sizing.

The question of a watermark is now so well known that one would hardly have thought it possible that it could have been overlooked, and yet in more than one instance within my experience a watermark has afforded conclusive evidence of forgery. I have also had instances of forged watermarks which have been made by impressing paraffin wax into the paper. These could be detected by chemical methods.

All the earlier investigations of disputed documents were concerned with the character of the handwriting, and it is only within comparatively recent years that scientific methods of examination have been used. There is one kind of fraud which appears to be more common in America than in this country, and to the detection of which the most scientific methods of examination have been applied. That is the imitation of a signature by means of tracing. In some notorious cases the original pattern from which the document was traced has been found and the exact correspondence between it and the disputed signature has been shown by photography beneath glass ruled with squares. In the Rice-Patrick case, in which the signatures upon four pages of a will were thus proved by Mr. A. S. Osborn, to be identical in form, the Court pronounced the deed to be a forgery. An American counsel in the course of his speech in one of these trials remarked: "It has been said that if a person meets in a waste place three trees growing in a row, he thinks they were so planted by man; should he find the distances equal he is convinced. Such accidental situation of thirty trees would not exceed in strangeness a coincidence like the one in this case."

To the same class of evidence belong conclusions to be drawn from coincidences in typewritten matter on different documents, or from the correspondence of the torn edges of receipt stamps.

In communications to other Societies, I have shown the means by which it is possible to distinguish between the marks made by different inks and different kinds of copying pencils, and, under certain conditions, those of ordinary lead pencils; and I have also shown to what extent it is possible to form an estimate of the age of ink in writing by means of microscopical and chemical tests. To go fully into these questions would carry me far beyond the time which is at my disposal this evening, but I might perhaps allude to the importance which often attaches to proving the sequence of strokes in writing. In the case of Rex *v.* Cohen, for instance, such proof was fairly conclusive of the correctness of the statement of the accused person.

All scientific work is now so highly specialised that no one can hope to keep fully in touch with all its branches. And this will be increasingly the case in the future, for the workers in each division of a science, such as chemistry, have no time to become acquainted with all the results obtained in other divisions of their particular subject. And yet, as I have attempted to show this evening, there are numerous directions in which new scientific researches may be applied to the problem of the investigation of crime. What is required is a certain degree of co-ordination among scientific workers, so that new methods most suitable to any particular problem may be immediately applied. So far as I am aware, we have no criminological society in this country such as is to be found in France, to which all who are concerned with the subject can contribute the results of their experience. We have, however, in the Medico-Legal Society, of which our Chairman to-night is the President, the possible nucleus for such an association. It might be found possible for that Society to extend its scope along the lines that I have suggested, but in order adequately to fulfil such a function that or any similar Society would have to receive the active support of the authorities in control of criminal investigation in this country.

DISCUSSION.

THE CHAIRMAN (The Right Hon. Lord Justice Atkin) said he was sure all those present would wish him to express their thanks to the author for his extremely interesting and valuable paper. He did not think there could be a more important topic for general discussion and general interest than the subject of crime and its prevention. It would probably be agreed that the first essential for the detection of crime was that members of society as a whole should be interested in its detection, and should play their part in helping the authorities to put it down. Crime was a pathological state in the body politic; it meant that society was suffering. There could be no well-ordered civilised society unless its members recognised that the rules under which that society existed must be observed and regarded an offence against those rules as an offence against themselves, so that if they saw a violation of the rules they would help to bring the offender to justice. There was no doubt that science played an important part in respect to crime: as the author had said, it played a very important part in the investigation and detection of crime, and he thought it also played a very important part in helping criminals. He was not quite sure whether in the last fifty years the advance of science had helped criminals or the police authorities most. Science had helped the forger, the coiner and the burglar, and had even extended assistance to the murderer, owing to the greater number of poisons that were available to him. Probably the most effective help it had given to the criminal was in improving his means of transport; assisted by a motor car or motor cycle he had very much better chances of evading the police than when he had to go to the nearest railway station and take an early morning train. Fortunately, however, science provided its own antidote, for it was being increasingly used in the detection of crime. One of its chief uses in that connection was with regard to identification, especially by means of finger prints. That method of identification was now thoroughly established, and was absolutely essential for a well devised system of classification and identification of criminals. It was of the greatest importance in preventing criminals losing their identity by changing their name and appearance. If the prison authorities once had a man under their control and he came to them again he could not escape detection as being a previously convicted criminal, and that was a matter of the very first importance in regulating crime. He did not think that that method was used for the actual detection of crime to such an extent as might be supposed from reading detective stories. In his own experience as a judge, he remembered practically no case where evidence as to the identity of a prisoner was given by means of the man's finger prints which he had left on the scene of the crime. The very simple expedient of wearing gloves was apt to destroy the necessary evidence in that respect. He had no doubt, however, that if an old convict did leave a finger print, the fact that he had been there could very easily be detected according to the present system, but it was obvious that unless a finger print could be identified as that of a person whose finger prints were already

registered one was not helped very much in detecting the person who had committed the crime. Identification no doubt was one of the great difficulties in criminal trials, and was one of the points upon which evidence might most easily break down. He was glad to say he had known very few cases in which a jury had been inclined to convict merely upon the evidence of identification. Witnesses who spoke to identification were so often inaccurate in their observation and certain in their conclusions that there were many opportunities for mistakes being made. He remembered trying not very long ago a case of a man charged with murder where the evidence of identification against him—which happened to be almost the only evidence against him—was that of a lady who said she had met him and his victim one Saturday at mid-day in one of the London streets when people were coming away from their work. She had never seen him before, and on the occasion in question she had seen him coming along the road at a distance of a yard or two away, and she was quite prepared to swear to him about a fortnight afterwards. Though it was pointed out to her that a reward had been offered to anybody who could speak to the case and that a photograph of the man and his victim had been published in a newspaper she admitted having read, she said that had no bearing at all on the conclusion to which she had come. There was another witness who also had only seen the man once for about half a minute, when he was taking a ticket at a booking office, and that witness was also prepared to swear to the man's identity as being the man who was there. That was not satisfactory evidence, and the prisoner was not convicted. The author had referred to the question of hair, and he thought the information given in the paper on that subject and also on the kindred subject of paper fibre was capable of being of extreme use in the detection of crime. A matter that was probably of extreme importance nowadays, but that had not been fully discussed, was the question of typewritten documents. If the kind of machine used and its age and characteristics could be identified by the type of a typewritten document, he thought that would be information that would at times be of the greatest value to persons engaged in the investigation of crime. He had listened to the paper with the greatest interest. If he were concerned at all in the hearing and determining of criminal cases, he was sure the paper would be of extreme value to him, and it certainly would be very valuable to those who were concerned in the investigation and detection of crime and in the trial of criminal cases.

Sir Basil Thomson, K.C.B., Director, Special Branch, Metropolitan Police, said he thought the paper had opened up new ground even to those who were charged every day with the detection of crime. It had to be borne in mind that if every man who committed a crime knew beforehand that he was bound to be found out there would be very little crime. The truth of that would be realised by anybody who read about crime in London about 150 years ago. In those days the Bow Street Magistrates were the supreme police authorities, and there were eight Bow Street "runners," who were responsible for dealing with all the major crimes, not only in London but in the whole of England. The present force was about 900, but the actual police force in London, with a population of between seven and eight millions, was 21,000 men. The police force in New York, which was believed to be a fairly efficient one, was only 10,000 for a population of six millions. Wherever there existed a sufficiently large and well trained police and a public that was anxious to help in the administration of justice, crime was found to be less than in other countries. During the police strike two years ago, when Hyde Park Corner, for instance, was left without policemen to control the traffic, there were very few, if any, accidents, the fact being that the traffic controlled itself, just as where the whole population was against the commission of crime, crime was reduced very much. He had collected some statistics with regard to crime in Paris, Chicago and London which were rather interesting. During the five years from 1903 to 1908, in the Department of Seine, which included Paris, there were 737 murders in a population of 2½ millions: in London there were 106 murders, and in Chicago, with a population of only two millions, there were 693 murders. The curious point about that was that the number of arrests was very nearly the same in the three cases—about 60 per cent. Turning to ordinary crime, such as burglary, theft, fraud, and so on, 150 years ago the depredations on the Thames alone were estimated at over £1,000,000, and about the same time, 1752, when Henry Fielding was a Justice of the Peace, it was almost a weekly occurrence for the mail coaches from the North to be stopped on the outskirts of London by highwaymen. Fielding managed to put a stop to that for a time by posting ex-cavalrymen with pistols at different points on the road, but a few years later the highwaymen started again. If the illegal acquisition of other people's property could be made a painful process that must bring its own punishment, such a proceeding would be practically stamped out. There was still a very large body of professional criminals, and he had had some experience of them because he was Governor at Dartmoor for seven years, and a good many of the men told him why they adopted pocketpicking, for instance, for a livelihood. One such man said he could make £30 a day at the races, and it was no use pointing out to him that he spent most of his time in prison. It was a gambler's life, but if the man knew that if he put his hand into another man's pocket on the race course he

was bound to be caught he would think twice about doing it. With regard to the training of detectives, he had personally given some attention to the matter. The training was non-scientific, because such an enormous field would have to be covered if every detective was trained to be a scientific investigator. What was aimed at at Scotland Yard was to train the intelligence of the detectives and let them know where they could obtain the help of an expert. They were given, for instance, a cursory knowledge of precious stones, and an expert on the subject could always be called in when required. The advantage the professional detective had over the amateur was that he had behind him a machine. Not very long ago there was a case of a woman who was decapitated and her body thrown over some railings into the garden of a London square. There were no means of identifying her at all except a laundry mark, and by circulating that laundry mark the police were able to identify the woman and discover the man with whom she had been associated and who had committed the murder. It was that machine behind him which gave confidence to the individual detective.

Sir Archibald Bodkin said he had listened to the paper with the greatest interest. The practical application of science to the investigation of crime was a little apart from the duties he had to perform, which lay more in the direction of assimilating the discoveries of other people, but the subject was one of intense interest. The great difficulty that was encountered in the majority of cases was the difficulty of identification. It was very seldom that a criminal left behind him such undoubtedly identifiable traces as finger prints, but that, of course, did not in the slightest degree minimise the great importance of the scientific study of finger prints. A very interesting topic dealt with by the author was the difference in the various fibres of which paper was made. He remembered a case a great many years ago in which the question was very carefully investigated. It was a case of forgery of a will purporting to have been made in the year 1542. Everybody knew it was a forgery, and the question was how to prove it to the satisfaction of the jury. It occurred to him at the time that the paper used in olden times was very different from modern paper. The paper on which the will was written was examined with the greatest possible care and was found to be absolutely contemporaneous with the apparent date of the will. In that instance science certainly did not assist in the detection of crime, which was detected by a purely accidental circumstance. A certain gentleman at that time used to spend his long vacations in studying fifteenth and sixteenth century wills, and for some reason or other he had made lists of a number of wills of the period of the particular forged will in question. He had noticed that some of those wills were written upon paper that was folded double, and he had noted that fact in the list of wills he had made for his own amusement. He was induced to go to the particular part of the country in question and go through the wills again in the individual Diocesan Registries, and he found a genuine will filed which was on a single sheet of paper. On the forged will being sent to that Diocesan Registry and compared with the single sheet it was found that the irregular edges of the two fitted together, and that showed how the sixteenth century paper had been obtained for the purpose of making the forged will. He thought it would be very useful if some of those present who were practically engaged in the investigation of crime would give their views on the subject in the course of the present discussion. He did not think it would be possible to make every detective a scientific investigator; there were experts to whom the detective could go in any particular case. In conclusion he would like to express the opinion in the hearing of the Chairman that if any person could apply the principles of science to the elucidation of the law of this country, it would be of the greatest possible practical utility.

Dr. Bernard Henry Spilsbury, M.A., M.B., said that science was of very great assistance in the investigation of crime at the present day, but it was unfortunately also true that every branch of science afforded valuable aid to the scientific criminal. One of the problems that had to be faced in the immediate future was that of meeting the cleverness of the highly intelligent criminal who made use of modern scientific methods to effect his ends. Some problems which in the light of present knowledge seemed insoluble would probably have to be faced before very long. The author had shown the wide application that the microscopic examination of hairs had in various classes of crime, and during the last few years that method of investigation had acquired an added interest owing to the great frequency with which furs were being worn by both sexes. Three or four years ago he came across an interesting example of that mode of investigation in connection with a crime in which a young married woman was found dead in a country lane with her throat cut. Her husband was charged with being the cause of her death, and at the husband's lodgings was found a blood-stained razor belonging to him, on which were certain hairs. The murdered woman was found wearing a necklet which had been cut by the weapon used, and when the hairs on the razor were compared with the hairs of the fur they were found to be microscopically identical. That also threw light on the way in which the murder had been committed, because the necklet must have been cut through by the razor after the razor had made the wound in

the neck and when it was moist with blood and the hairs would therefore adhere to it. That was only one of several instances he had recently encountered in which the study of hairs had been of value in connection with that class of crime. The investigations of scientists had made it possible to distinguish the blood of one species of animal from that of others, but in that connection it had hitherto been regarded as a difficulty that the blood of man might not be distinguishable from that of anthropoid apes, and in certain other species of animals that were closely allied the same difficulty might arise. The most recent investigations, however, had shown that if the blood was further tested the reaction which was given by the specific blood was a much stronger one than that given by the blood of the allied animal. Science had also shown that there were three or four different kinds of blood possessed by different individuals, and for the purpose of transfusion of blood the donor and recipient must possess the same kind. Another scientific discovery, which, so far as he knew, had not yet been applied to the investigation of crime, was that other tissues of the body besides the blood could be distinguished as belonging to men or animals. For example, if brain matter was found on a man's clothing or scattered on the floor, it was possible by applying the same tests to say whether it belonged to man or to some other animal, although the method used was a very arduous one. On the other hand, bacteriology had afforded considerable assistance to the scientific criminal. Even before the recent war, a man in Germany had been convicted of causing the death of several people by the administration to them of cultures of living bacteria. That means of causing illness and death was a most deadly weapon, and its use would be extremely difficult to prove in some cases. Science had also shown that in bacteriology poisons of an infinitely greater degree of toxicity than any of those known to the toxicologist could be obtained and isolated in a concentrated form. Some of those poisons, if obtained in a sufficiently concentrated form, could produce their lethal effect in extraordinarily minute doses, and be so absorbed into the human body that, as far as was known at the present time, there were no means of detecting them after they had had their effect. One of the great difficulties that would have to be faced in that connection was that the scientific criminal, if he had had a bacteriological training, might be able to obtain those poisons and apply them for unlawful purposes. During the war a colleague of his had come across an instance of the application of bacteriology for unlawful purposes. A number of young Jews from the east end of London were found to have infected their sputa with tuberculin—a dead culture of the tubercle bacillus, used for inoculation into persons suffering from tuberculosis as a curative measure—in order to evade military service by giving the impression that they were suffering from tuberculosis. The investigation of crime was becoming so complicated and extensive, in view of the application of various kinds of special methods, that it was obvious that all criminal investigation must be carried out by means of team work, different men undertaking different branches of the subject. In some cases, where sufficient data were available, a crime could be completely reconstructed. He thought it probable that the greatest progress in the detection of crimes of violence would be made in connection with the reconstruction of crimes by careful and accurate observation of the victims and their surroundings.

The Hon. Trevor Bigham, C.B. (Director of Criminal Investigation, New Scotland Yard), said it was sometimes stated that the police did not make enough use of science, but he could only say that whenever they did get a case where scientific systems appeared to be demanded they were only too glad to employ them. The trouble was that there were so few cases in which science could assist. At least nine-tenths of the work of the police consisted of trying to find out who committed a crime without any data whatever, and they had to resort to methods which could scarcely be called scientific. The Chairman and Sir Archibald Bodkin had made some remarks about the use of finger prints in detecting crime, but of course 98 or 99 per cent. of the cases in which finger print methods were used were in the identification of men who were in custody and in determining whether or not they had a criminal record. The reason why finger prints were so seldom used as evidence to connect a person with an undiscovered crime, was that they were very seldom found, and, when they were found, in 60 or 70 per cent. of the cases they were so blurred as to be useless for purposes of identification. If a single clear finger print was found it was very difficult to identify it as belonging to any particular individual, for no satisfactory way of classifying single finger prints had yet been discovered. Research work had been done on the subject both in this country and elsewhere for some time, and it was quite possible that some practical results might be obtained. One subject which had not been referred to was the system of classification of criminals by the methods they adopted. It was found that in certain classes of crime, especially in what he might call fraudulent crime, there was a strong tendency on the part of individuals to follow the same methods over and over again. A great deal of work had been done of late years in classifying known criminals according to the methods they adopted, and in London, Wakefield, and elsewhere, there were elaborate indexes of known criminals classified in that way. That had been found in a considerable

number of cases to enable the police to detect a culprit when there was very little evidence against him. The indexes were not based entirely upon the methods adopted but also upon characteristics such as a North country accent or a scar or a limp, or any other physical characteristic. The Chairman had said he did not know whether science had helped the thief more than the police, but personally he had not the least doubt about it; the detection of ordinary crimes, such as burglary, was much more difficult at the present time than it was a hundred years ago. The present rapid means of transit were a very great advantage to the professional thief, and one of the great problems at the present time was to devise some means of catching a man who lived at one end of London and worked at the other end where he was not known. He agreed with the author that there ought to be some Society where scientific information which might be of use in the investigation of crime could be collected. One of the chief difficulties of the police in this country was that they did not hear of the various discoveries that were made. It might be that at the moment no practical application of a particular line of research could be seen, but it might suggest lines of enquiry to the police officer which would never enter his mind otherwise. There was a very real need for such a Society as had been mentioned, or for a periodical that would serve the same purpose.

A hearty vote of thanks was accorded to the author for his valuable paper, and the meeting terminated.

THE CARPET WOOLS OF AZERBAIJAN.

The different classes of wool produced in Persian Azerbaijan are: (1) Khoi wool, which is produced in the north-western part of Azerbaijan, in the districts around Khoi and Maku; (2) Urumiah wool, which is produced South-west of Lake Urumiah, in the Suduz district of Urumiah and Ushnu; (3) Soujbulak wool, produced South of Lake Urumiah; (4) Sakiz wool, produced South of Lake Urumiah; (5) Salmas wool, produced West of Lake Urumiah; (6) Karadagh and Ardabil wools, produced in the North-Eastern part of Azerbaijan, in the district between Tabriz and the Caspian Sea.

Khoi, Urumiah, Soujbulak, and Sakiz wools are all suitable for use in the manufacture of carpets. Khoi wool is the finest carpet wool produced in the Province, and Sakiz wool the poorest. Khoi wool is long and of a soft, silky texture. The best Khoi wool is produced in the vicinity of Maku. Urumiah wool is inferior to Khoi wool, and Soujbulak wool is coarser than Urumiah wool. After being washed Soujbulak and Sakiz wools are of practically the same quality, but the unwashed Sakiz wool, which is commonly sold in the market, is dirtier and dustier than unwashed Soujbulak wool.

Salmas wool is short, coarse, and usually red in colour. It is not suitable for carpets, and is used by the native population for making clothing and bedding. It is rarely exported from the region in which it is produced. Karadagh and Ardebil wools are also unsuitable for carpets and are almost entirely used by the native population for making clothing and bedding.

From a report by the U.S. Consul at Tabriz, it appears that sales of wool are effected chiefly by individual bargaining between the wool buyers and the owners of the flocks. The only transport available in Azerbaijan is pack animals, and in transporting wool to the markets, it is packed in bags which can be slung over the backs of the animals. The wool is not compressed in packing because there are no presses, and because wool which has been compressed in packing is not suitable for use in the manufacture of carpets.

HAIR-NET INDUSTRY OF CZECHO-SLOVAKIA.

Among the principal Bohemian and Moravian exports to the United States have been human hair and hair nets. It is estimated that 80,000 people are employed in making at their homes human hair products, mainly in winter, when they are not working in the fields.

According to a report by the U.S. Trade Commissioner, at Prague, the centres of the industry are Chotebor, Kamenice, Chrudim, Chrast, Nemecky Brod, Libice, Jihlava, Krucemburk, and Studenec. There are several firms in Chotebor, Chrast, and Jihlava which buy nothing but Chinese hair and prepare it into various colours and shades. Hair already prepared was imported from Germany and France. The industry has spread to about 20 communities in the Mikulov and Hustopec Counties in Moravia. In wintertime there is hardly a family in the localities named in which the women do not make hair nets. One person makes from 3 to 6 dozen a week, according to quality and size. The workers are paid according to the density of the meshes and the size of the nets.

Originally nearly all the work was done through factors, for Vienna houses. Recently many domestic firms have been established. There are many entrepreneurs in Bohemia and Moravia that deal in hair nets and other human hair manufactures. Each of them has its factors and they in turn employ women workers to whom they furnish the necessary raw materials. Exports to the United States ceased during the war, but have commenced again. The greatest quantity has been exported to Germany; France and Great Britain have also bought considerable quantities. According to Otto's

Commercial Encyclopedia, the greater portion of the German and French imports was re-exported as manufactures of those countries.

During the war the number of people working in the industry was greatly reduced on account of other necessary work. There was plenty of raw material and the manufactured hair nets were exported principally to Germany and neutral countries. After the overthrow of the Austro-Hungarian Government, when many men returned from the front and could devote themselves to work in the fields, the making of hair nets on a big scale was renewed, and on account of the great demand for the goods and the high wages thousands of new people entered the industry. Both cap nets and fringe nets are made, and before the war "points" found their best market in the United States.

MARKET FOR AGRICULTURAL MACHINERY AND IMPLEMENTS IN MANCHURIA AND SIBERIA.

The wide plains and the rolling country of Manchuria and of south-eastern Siberia are much more suitable for the use of agricultural implements and machinery than most regions of China proper, where the present methods of agriculture make hand cultivation necessary. The fields of China are usually subdivided into very small plots, belonging to different owners, planted with different crops, which vary with the nature of the soil, the system of rotation, and the desires of the farmers. The numerous graves, boundary ridges, irrigation ditches, raised paths, scattered habitations, and other obstacles make the operation of even horse-drawn agricultural implements extremely difficult.

In Manchuria, however, where the population is not so dense, these obstacles are rare, and wealthy men or Government colonization companies possess great tracts, sometimes containing from 10,000 to 20,000 acres, planted with a few staple crops in large fields, which resemble those of the United States. The holdings of the Russian peasants in south-eastern Siberia often run from 50 to 150 acres, though, of course, there are many much smaller, and they are planted with relatively few crops in such a manner as to make possible the use of farm implements of various kinds. The marked tendency of the Russians towards co-operative enterprises may also make it possible for a village to purchase machinery which would be beyond the means of any individual in it.

The great opportunity, however, in Manchuria, according to a recent report by the U.S. Trade Commissioner at Vladivostok, is for the introduction of bean harvesters and thrashers of about four to eight horse-power suited to soya bean, which furnishes the principal export crop.

There is a market in Manchuria for thrashing machines with cylinders not to exceed 28 inches, and of about 8 horse-power, mounted on wheels, and for small mills to husk rice, kaffir corn, and millet, as well as for flour mills for wheat and other grains. Some of these small devices can be seen in successful operation in Mukden and in other places in spite of the expensive fuel required, as most of them use kerosene or motor spirit. In Mukden and Harbin electricity is available, and there are coal supplies in several places.

While there is little immediate necessity for the use of labour-saving devices in Manchuria, as coolies can be secured in practically any number from Shantung for planting and harvesting, the native contrivances, and even horse-drawn ploughs, find it almost impossible to break up the virgin soil of the more remote districts, where the heavy soil is made into an almost impenetrable mat by the roots of grasses and other plants. Tractors are well suited to plough this land, and it seems feasible for companies to own tractors and either to lease them to the owners of the land or to take contracts for the ploughing.

In many sections it is difficult to open up the country on account of the biting flies and other insect pests. A great many horses are lost following their attacks. This is an additional reason for the use of machinery.

Large numbers of mowing machines, hay rakes, and hay presses have been sold in certain sections of north-eastern Asia, and are regarded with favour for preserving the native grasses, which must be cut green, as they lose much of their nutriment if allowed to dry out naturally. The flat, virgin soil of Siberia is especially adapted to the use of mowing machines and to cattle raising, which is a customary occupation of the Russian peasants. As the demand increases for meat, wool, hides and hair, it is probable that hay-making machinery will be used in considerable numbers in Siberia, and later in Manchuria and Mongolia, as the people realize its advantages and become accustomed to its use.

Careful management and intelligent supervision will, of course, be required for success in the use of machinery or complicated horse-drawn implements. The large steam ploughing machines have, in some cases, not proved successful owing to a lack of understanding of their mechanism on the part of the operators.

The Russian farmers in Siberia have for years been buying large quantities of American tools and implements, and have experienced relatively little difficulty, in many cases showing considerable mechanical ability, as about 75 per cent. of the purchasers were able to put together those shipped "knock down" and operate them without any other assistance than that contained in the regular books of instruction sent with them.

The Chinese, quite naturally, have no ex-

perience with machinery and have had trouble not only in putting the machines together, but in their use.

It is, therefore, desirable in Siberia, and essential in Manchuria, adds the Trade Commissioner, to send with machines competent foreign mechanics to train the operators in the use and maintenance of machines. In many cases branch offices should be established to supply lost or worn-out parts and to render continuous service in making repairs both of machines and implements. The lack of such service has been the cause of failure in many instances.

WOOL INDUSTRY IN BOLIVIA.*

In spite of the adaptability of much of Bolivia to the raising of wool bearing animals, the development of the foreign wool trade of the country is of quite recent date, and much remains to be done before the sheep-raising industry is put on such a modern basis as it has reached in Argentina and Uruguay. During the past decade there has been a very marked increase in the exports of wool. Whereas, in 1911 only about 17,000 kilos of sheep's wool were exported, in 1918 exports of Bolivian wool had increased to 725,557 kilos of sheep's wool, 191,806 kilos of alpaca wool, and 146,574 kilos of Llama wool.

From a report by the U.S. Trade Commissioner in Bolivia, it appears that sheep are found throughout the highland region of Bolivia, but little serious attention is given to their breeding. The stock consists of the old degenerated merino breed brought in by the Spaniards and allowed to increase and deteriorate with what little care the Indian shepherds are disposed to give to their flocks. These vary in size from a few sheep to 8,000, flocks of the latter size, however, being very rare even in the Department of La Paz, which is the centre of the sheep-raising industry of Bolivia. There is ample pasturage and water over large areas of the upland departments to support many times the number of sheep now grazing there. The wool taken from these sheep is short, the clip from each animal averaging little over 2 pounds of washed wool. Shearing takes place about once every two or three years. A sharpened piece of glass or tin is used for the operation, and the natives refuse to adopt the use of shears. In fact, a lot of a hundred shears which were brought into the country a few years ago found no sale, even though the importer made a personal demonstration of their use.

Probably half a million llamas inhabit Bolivia where they constitute the traditional pack animal of the Indian population. They are sheared at intervals of from two to five years, though often this operation does not take place until after their death. When sheared every two years each llama gives about five pounds of wool, which is somewhat coarse and always very dirty. The natives employ it very widely in their weaving. Llama wool brings about the same price in Bolivia as unwashed sheep's wool.

There are some 200,000 alpacas in Bolivia, although no effort has ever been made by the Government to take a census of either the alpacas or llamas in the Republic. The animal belongs to the same family as the llama and the vicuna, but its legs are shorter than those of the llama. The alpaca only lives in certain districts, the most favourable to its growth being the region about Lake Titicaca and the Province of Carangas in the Department of Oruro. The centres of the alpaca wool trade are Charana and Puerto Acosta. The former town lies on the line of the Arica-La Paz Railway at the point where it crosses the border into Chile, and serves as the outlet for the alpaca wool supply of the Carangas country; Puerto Acosta is situated on Lake Titicaca. The Bolivian Government has been desirous of stimulating the raising of alpacas, and a few years ago gave a concession for that purpose, but nothing has yet been done to comply with its terms beyond the maintenance of a single alpaca on the property near Lake Titicaca which was originally granted to the company. Most of the herds of alpacas belong to Indians, who give them little attention, but who at least understand the peculiarities of the animal, and are able to domesticate it. A more careful study of alpaca raising has been made in the Arequipa district of Peru than has been made in Bolivia.

It is customary to shear the herds every two years, though many are sheared at much longer intervals, even of five years. About 10 pounds of wool are generally obtained from a single alpaca. The colours most frequently seen are various shades of brown and black; white animals are much rarer. In addition to the use of alpaca skins as material for clothing, they serve as rugs which sell for from 100 to 200 bolivianos (1 boliviano equals about 1s. 7d. normally), the price depending upon size and colour. The alpaca is sometimes crossed with the llama, the wool of the hybrid animal being sold as alpaca wool.

*See also the paper on "The Breeding of Sheep, Llama and Alpaca in Peru," by Colonel Robert J. Stordy, C.B.E., D.S.O., published in the *Journal* of January 14th, 1921.

THE PICTURE POSTCARD INDUSTRY IN GERMANY.

Conditions in the German picture post-card industry do not appear to be particularly encouraging, this branch of trade probably having suffered more from the general increase

in prices than any other German industry. One concern after another has been forced to discontinue that line of business. The situation is traceable, writes the representative at Berlin of the U.S. Department of Commerce, not so much to increased wages and cost of raw material as to the Government's increase of postage on post-cards from 5 to 30 pfennigs, with the resultant decreased demand for the cards.

Prior to the war, the monthly average of picture post-cards manufactured in Germany under the phototype process was 32,000,000. By the end of 1920 the average was around 7,000,000 The selling price of picture post-cards in Germany has increased from 200 to 300 per cent. over the pre-war prices, while postage, as mentioned above, has increased sixfold. The greater number of post-cards being marketed in Germany to-day originate from old stocks. According to the technical bureau of the Association of Lithographers in Leipzig, there were manufactured in that city by 25 plants, large and small, during the first six months of 1913, a total of 241,308,615 picture post-cards. During the first six months of 1920 these same plants produced a total of 15,838,220 cards. The 65 factories in Berlin, during the period of May to July, 1914, reported a total output of 265,000,000 cards, while during the same period for 1920 the total was only 24,000,000 cards.

These Berlin plants during the same period of 1914 employed a total of 14,800 workmen, as against 5,200 during the corresponding period for 1920—a shrinkage of almost one-third. It should be explained, furthermore, that of these 5,000 many could readily have been dispensed with but were retained only because the Tarifamt (Wage Bureau) effected a reduction in working hours in order to avoid further increase in the number of unemployed. Until a short time ago, some 100,000 persons in Germany had derived their living from the manufacture and sale of picture post-cards.

The direct effect of the depression on such an extensive industry is obvious. As an indirect effect the paper mills have suffered heavily through lessened demand for their materials—a demand which has shrunk to the minimum.

COMMERCIAL POSSIBILITIES OF THE NIPA PALM.

It is stated that the nipa palm (*Nypa fructicans*) is one of the very few tropical plants which occur in pure stands over extensive areas in Borneo. In common with many other palms its sap contains sugar, and laboratory experiments conducted at the Bureau of Science, Manila, indicate that production of sugar from nipa palm sap would be a commercial success. According to these experiments, it is estimated that there would be at least 12 per cent. of recoverable sugar in the sap, and the average annual yield of 4,000 gallons of sap per acre of nipa under management should produce about 4,000 pounds of sugar.

Although the production of sugar from nipa sap is still in the experimental stage, writes the U.S. Consul General at Singapore, the manufacture of alcohol from the same source is a well-established industry. For many years the natives of the Philippines have been producing a low-grade distillate averaging about 25 per cent. alcohol, which has been used as a beverage. Lately the crude stills which produced this distillate have largely been replaced by modern distilleries, 75 of which were in operation in 1913. These produced 2,500,000 gallons of distilled spirits. Over 98 per cent. of this production is diluted and used for beverages and the balance utilized as fuel for lamps, stoves, and motors.

The cost of the distillate as at present produced in the Philippines is difficult to determine, because operations are scattered, manufacturing processes are not well controlled, and the cost of collection of the sap is not uniform. The average cost of collection seems to be in the neighbourhood of 4s. per 100 gallons, but it is often collected at a much lower cost. In a compact, well-managed area it should be possible to collect and deliver it at the distillery at a cost of 50 or 75 cents per 100 gallons; and this quantity of sap should produce between 6 and 7 gallons of alcohol, which places the cost of the raw material at 8 to 12 cents per gallon of alcohol. The plant needed for distillation is of very simple design and should not cost more than $15,000 for a 500-gallon per day unit. Including wages, fuel, and interest on the investment, the estimated cost to manufacture should not exceed 10 cents per gallon of alcohol, and the total cost of production should not exceed 20 cents. per gallon. Experts who have operated in the Philippines maintain that a well-organized plant operating near well-managed and concentrated areas of the palm can produce at a cost of 14 cents or less per gallon.

The nipa palm grows in dense formation on tidal areas throughout all the eastern Tropics. Very extensive areas are to be found in Borneo, and the British North Borneo Government estimates that at least 300,000 acres exist at very accessible points throughout their territory. One block of 57,000 acres has already been surveyed on the west coast, and certainly another 100,000 acres can be reached within four hours by launch from Sanadakan on the east coast, and yet another 100,000 acres near Tawan, on the east coast, but farther south.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at 8 p.m., unless otherwise announced:—

APRIL 27.—SIR JAMES P. HINCHLIFFE, Chairman of the British Research Association for the Woollen and Worsted Industries, "Research in the Wool Industry." SIR THOMAS H. MIDDLETON, K.B.E., C.B., LL.D., will preside.

MAY 4, at 4.30 p.m.—SIR GEOFFREY G. BUTLER, K.B.E., Director, British Bureau of Information, U.S.A., 1917-19, and Member of Executive Committee, Reunion of British War Mission to the United States, "Anglo-American Relations: a Personal Impression." THE RIGHT HON. VISCOUNT BRYCE, O.M., G.C.V.O., D.C.L., F.R.S., in the Chair.

MAY 25.—DR. C. M. WILSON, "The War and Industrial Peace: an Analysis of Industrial Unrest."

MONDAY, MAY 30.—SIR KENNETH WELDON GOADBY, K.B.E., Medical Referee for Industrial Poisoning, County of London, "Immunity and Industrial Disease."

INDIAN SECTION.

At 4.30 p.m.

TUESDAY, MAY 3.—WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India." SIR ROBERT W. CARLYLE, K.C.S.I., C.I.E., late Member of the Government of India, in the Chair.

FRIDAY, JUNE 10.—SIR GEORGE SEYMOUR CURTIS, K.C.S.I., Member of the Executive Council, Bombay, "The Development of Bombay."

INDIAN AND COLONIAL SECTIONS.

(Joint Meeting.)

At 4.30 p.m

FRIDAY, MAY 27.—SIR CHARLES H BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

CANTOR LECTURES.

Monday evenings at 8 o'clock.

SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.D., Lecturer in Spectroscopy at University College, London, "Recent Applications of the Spectroscope and the Spectrophotometer to Science and Industry." Three Lectures.

Syllabus.

LECTURE III.—APRIL 25.—The significance of Absorption spectra. Studies on the Ultraviolet absorption spectra of Blood Sera, Uric Acid, Cellulose Films, etc. Applications of Spectroscopic Instruments to the technological study of Fluorescence in Paper, Textiles and other materials.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, APRIL 25 .. Electrical Engineers, Institution of, (Informal Meeting), at the Chartered Institute of Patent Agents, Staple Inn Buildings, Holborn, W.C., 7 p.m. Mr. C. L. Lipman, "Engineering in Russia."

East India Association, 3, Victoria Street, S.W., 3.45 p.m. Mr. E. A. Molony, "Early Hindu Polity in Kashmir."

Architectural Association, 34, Bedford Square, W.C., 8 p.m. Sir Lawrence Weaver, "Rural Cottages: Common Sense and Architecture."

TUESDAY, APRIL 26 .. Post Office Electrical Engineers, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m.

Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Mr. W. J. Jones, "Ship-Lighting in relation to Comfort, Safety and Efficiency."

Royal Institute, Albemarle Street, W., 3 p.m. Prof. A. Keith, "Darwin's Theory of Man's Origin (in the light of present day evidence)." (Lecture II.)

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. C. Jones, "Memorial Lecture on the Life Work of Sir William Abney."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Sir Francis Fuller, "The Romance of Ashanti."

WEDNESDAY, APRIL 27 .. Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street Adelphi, W.C., 5.30 p.m. Dr. T. D. Bosworth, "The Mackenzie Oil Field of Northern Canada."

Sanitary Institute, 90, Buckingham Palace Road, S.W., 5.30 p.m. Colonel C. H. Melville, "Some Lessons of the War."

Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 7 p.m. Mr. H. L. Heathcote, "The Ball Bearing in the Making, under test, and on Service."

Physics, Institute of, at the Institute of Civil Engineers, Great George Street, S.W., 6 p.m. Inaugural Address by Sir J. J. Thomson.

British Academy, King's College, Strand, W.C., 5 p.m. Mr. J. Masefield, "Shakespeare."

Oriental Studies, School of, Finsbury Circus, E.C., 12 o'clock. Miss Alice Werner, "European Expansion in Africa." (Lecture I. "The Dutch in South Africa.")

Electrical Engineers, Institution of (South-Midland Centre), The University, Birmingham, 7 p.m. Mr. E. A. Watson, "Magnetos for Ignition Purposes in Internal Combustion Engines."

THURSDAY, APRIL 28 .. Royal Institution, Albemarle Street, W., 3 p.m. Mr. H. S. Foxwell, "Nationalisation and Bureaucracy." (Lecture II.)

Botanic Society, Inner Circle, Regent's Park, N.W., 5.30 p.m.

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. 1. Mr. J. R. Blackie, "Electricity Supply — Present Conditions and the Hopkinson Principles." 2. Mr. J. W. Beauchamp, "Multi-Part Tariffs for Domestic Electricity Supply."

Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Prof. F. C. Lea, "The Elastic Modulus of Concrete."

FRIDAY, APRIL 29 .. Royal Institution, Albemarle Street, W., 9 p.m. Sir Frank W. Dyson, "Advances in Astronomy."

SATURDAY, APRIL 30 .. Royal Institution, Albemarle Street, W., 3 p.m. Mr. H. Y. Oldham, "The Great Epoch of Exploration." (Lecture II.) (Spain.)

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FRIDAY, APRIL 29, 1921.

[*All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.* (2)

NOTICES

NEXT WEEK.

TUESDAY, MAY 3rd, at 4.30 p.m. (Indian Section.) WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India." SIR ROBERT W. CARLYLE, K.C.S.I., C.I.E., late Member of the Government of India, in the chair.

WEDNESDAY, MAY 4th, at 4.30 p.m. (Ordinary Meeting.) SIR GEOFFREY BUTLER, K.B.E., Director, British Bureau of Information in the U.S.A., 1917-19, and Member of the Executive Committee, Re-union of War Missions to the United States, "Anglo-American Relations: A Personal Impression." THE RIGHT HON. VISCOUNT BRYCE, O.M., G.C.V.O., D.C.L., F.R.S., in the Chair.

Further particulars of the Society's meetings will be found at the end of this number.

EIGHTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 20th, 1921: THE HON. SIR ARTHUR STANLEY, G.B.E., C.B., M.V.O., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Brooks, Professor Alfred Mansfield, A.M., Bloomington, Indiana, U.S.A.
Phillips, Trevor Watts, B.Sc., Assoc. M.Inst.C.E., Rock Ferry, Cheshire.

The following candidates were balloted for and duly elected Fellows of the Society:—

Andrews, Michael Corbet, F.R.G.S., Belfast.
Barber, Charles Oliver, B.Sc., F.C.S., London.
Bhutt, Professor, B.I., M.A., B.Com., Rajkot, India.
Blanch, J. M., London.
Bruce, John, Aberdeen.
Cruce, Rev. Frederick George Landin, M.A., Southsea.
Gantzer, Joseph Francis, Deoghar, India.
Griffin, Watson, Toronto, Canada.
Hussain, Khan Sahib Shariff, Lal Kua, India.
Lake, George Frederick, L.R.I.B.A., London.
McKay, Percy Hamilton, Kobe, Japan.
Mathur, B.D., Gwalior, Central India.
Ojha, Amrit Lal, Calcutta, India.
Sherwood, William John Lewis, London.

A paper on "(1) Thomson's Apparatus for Armless Men. (2) X-Ray Motor Ambulance Service for the United Kingdom" was read by SIR JAMES CANTLIE, K.B.E., LL.D., F.R.C.S.

The paper will be published in a subsequent number of the *Journal*.

INDIAN SECTION.

FRIDAY, APRIL 22nd, 1921; THE EARL OF LYTTON, Under Secretary of State for India, in the Chair. The Sir George Birdwood Memorial Lecture on "The Common Service of the British and Indian Peoples to the World" was delivered by LIEUT.-COLONEL SIR EDWARD W. M. GRIGG, K.C.V.O., C.M.G., D.S.O.

The lecture will be published in a subsequent number of the *Journal*.

Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council, presented to SIR VALENTINE CHIROL a medal for the Sir George Birdwood Memorial Lecture on "The Enduring Power of Hinduism," which he delivered in June, 1920.*

CANTOR LECTURE.

On Monday evening, April 25th, MR. SAMUEL JUDD LEWIS, Ph.D., D.Sc., F.I.C., Lecturer in Spectroscopy, University College, London, delivered the third and final lecture of his course on "Recent Applications of the Spectroscope and Spectrophotometer to Science and Industry."

*See *Journal* of August 6th, 1920, page 603.

On the motion of the Chairman, Mr. C. F. Cross, F.R.S., a vote of thanks was accorded to the lecturer for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

EXAMINATIONS.

The number of entries for the second series of examinations of 1921 which will commence on May 2nd is 38,501. The number of entries for the first series was 16,658, making a total for the year of 55,159. This is the largest number ever received, and is 1,118 in excess of the previous highest year, 1920, when the total for both examinations was 54,041. The total for the second series, 38,501, is the largest number ever received for a single examination, the previous highest having been in 1914, when there was only one examination, and the entries numbered 37,973.

THE DR. MANN TRUST.

Under the terms of the will of the late Mrs. Charlotte Elizabeth Mann, who died in her 98th year, on June 12th, 1920, the Society has received a legacy of £1,000. The clause in which the bequest is made reads as follows:—

"I bequeath to the Society for the Encouragement of Arts, Manufactures and Commerce the sum of £1,000 upon trust to invest the same in Government Securities or Debenture Stock of the Trunk Railways of Great Britain or any securities in which Trustees are now or may be hereafter authorised to invest trust money and to apply the annual income arising from such investment to defray the expenses of causing to be delivered annually in the rooms of the said Society by some competent lecturer two or more lectures for the instruction of a juvenile audience to be called the 'Dr. Mann Juvenile Lectures,' and if at any time the interest arising from the said investment shall more than suffice to defray the charges of such juvenile lectures it shall be lawful for the Council or governing body of the said Society to expend such surplus in any manner they see fit, provided always that it be for the advancement of science and that the name of Dr. Mann be associated with any object to which it may be applied and further that if from the advance of knowledge or improvement of teaching methods or other causes it may seem desirable to the said Council or governing body of the said Society that the income from the said investment should be applied to other purposes than the delivery of lectures it shall be lawful for the said Council or governing body (with the approval of the President for the time being) to apply the said income in such manner as they may see fit, provided always that the said income be devoted to the advancement of science, and that the name of Dr. Mann be associated with any other object to which it may be applied."

Dr. Robert James Mann, who died in 1886, was born at Norwich in 1817, and was educated for the medical profession at University College, London. He graduated M.D. at the University of St. Andrews, and was in practice for some years in Norfolk. In 1853 the state of his health compelled him to give up regular medical practice, and he devoted himself to scientific and literary work.

In 1857 he left England for Natal, where he resided for nine years, during seven of which he was Superintendent of Education for that colony. In 1862, he was the chief organiser and despatcher of the exhibits of the colony in the Great Exhibition of that year in London, and he arranged and carried on a preliminary exhibition at Durban. He returned from Natal in 1866 with a special appointment from the Legislative Council to promote emigration, which he held for five years. In 1874 Dr. Mann was elected a life member of the Society of Arts and from 1874 to 1886 was Secretary to the African (now the Colonial) Section of the Society, and was an intimate personal friend of Mr. P. le Neve Foster and Sir H. T. Wood. He took a great interest in the work of the Society, read numerous papers here, mainly on subjects connected with Africa, and frequently spoke in the discussions. In 1886 he was elected a member of the Council, but he unfortunately died shortly after his election.

Dr. Mann took a keen interest in many branches of science, especially astronomy and physics, and was a prolific contributor to scientific periodicals. He was also for a long time on the staff of the *Edinburgh Review*.

The protection of buildings from lightning was a subject on which he wrote much, and for which he did valuable work. His attention was more particularly drawn to this subject by the prevalence of thunderstorms in Natal. In 1888 he provided the

funds for two lectures on the subject, and it was at the first of these that Sir Oliver Lodge described the early researches, which led to the valuable contributions he afterwards made to the discovery of wireless telegraphy.

Mrs. Mann was the second daughter of the Rev. John N. White, rector of Tivetshall, Norfolk. She was born in 1822 and married Dr. Mann in 1856. She accompanied her husband to Natal, and throughout their married life she was of great assistance to him in his literary and other work. After his death she wrote for private circulation a memoir of her husband.

PROCEEDINGS OF THE SOCIETY.

SIXTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 6TH, 1921.

MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

The CHAIRMAN, in introducing the author of the paper, said Dr. Barr was well known in connection with the wonderful Barr and Stroud range finders that had done so much not only for the Navy, but also for artillery in general, and it was interesting to note that a firm of instrument makers that had in the past been applying themselves entirely to purposes of warfare, were now adapting their workshops to apparatus that was essentially of a peaceful character. Everyone must sympathise enormously with those unfortunate people who were not able to see, and the paper to be read on the present occasion dealt with a wonderful instrument, the optophone, invented for them by Dr. Fournier d'Albe. It was a matter for congratulation that a great firm like Messrs. Barr & Stroud were taking an interest in that invention, and were putting it into a practical shape so that the blind might be able to make use of it.

The paper read was :—

THE OPTOPHONE.

By ARCHIBALD BARR, LL.D., D.Sc.,
Emeritus Professor of Engineering, University of Glasgow

The purpose of the instrument which I have undertaken to describe and to demonstrate to-night is to enable the blind to read ordinary printed matter such as books or newspapers. This is accomplished by producing in a telephone receiver a series of musical notes representing the various letters as these are passed over by the instrument in traversing a line of printing. The sense of hearing is thus used instead of the sense of sight.

Hitherto the blind have been dependent for their reading upon books printed on the Braille or on the Moon system. In Braille the letters (in a few cases combinations of letters) are represented by sets of dots embossed on thick paper. In Moon printing embossed characters are also used, but the forms are mostly simplifications of the capitals of ordinary block type. In either case the reader passes a finger along the line and recognises the letters by the sense of touch. Great proficiency can be gained in Braille reading by sightless persons who begin the practice very young; a speed of reading equal to that of ordinary speech is attained. But it is difficult for those who have lost their sight in later life to acquire the necessary delicacy of sensation to become expert, more especially perhaps in Braille reading. I understand that those who begin late in life require to have their fingers softened before entering on this course. But the great disadvantage of these systems is that they require specially prepared books, and these are exceedingly bulky, very costly, and soon become soiled if much used. Take, for example, copies of the Gospel of St. Matthew in small pica—a moderately large type—and in Braille and Moon. The Braille volume has 25 times the weight and the two volumes in Moon type 45 times the weight of the ordinary edition. The costs are, I understand, for Braille 2s. 6d., for Moon 9s, while the pica—a quite good edition—costs 6d. Only comparatively very few books are issued in Braille or in Moon characters (perhaps one in 10,000), and, of course, current literature is not available in either system to any extent. These disadvantages are overcome by the Optophone. It remains to be seen what speed of reading can be attained when the instrument has been fully developed and sufficient practice with it has been had, but the proficiency acquired by one or two readers is most encouraging. An obstacle to its very general use may be the cost of the equipment which at present may be put at about £100. If extensively adopted, the cost of production would, of course, decrease, and against the cost of the apparatus must be set the cost of printing a large number of books in Braille or Moon.

The instrument which I am about to describe depends for its action upon a very remarkable property of Selenium, a chemical element discovered in 1817 by the Swedish chemist, Berzelius. In the Mendeleeff Table of the Elements, Selenium stands between the non-metal Sulphur and Tellurium, which has sometimes been classed as a non-metal, but is now usually included among the metals. It is extracted from the mud found in sulphuric acid chambers. It has at least three allotropic forms, which may be called the vitreous, crystalline red, and crystalline grey (or metallic) forms. In the vitreous form it is deep red in colour, melts gradually on being heated, being soft at 60° C. and fluid at temperatures above 220° C. On prolonged heating at about 215° C. it changes to the grey crystalline form. In the vitreous form it is one of the best electric insulators. While it was in use as an insulator in submarine cable experiments on the Island of Valentia in 1873, one of the assistants engaged in these experiments observed that it was unreliable as an insulator when exposed to light. This hitherto unsuspected property was further investigated by Willoughby Smith, and it was established that the electric conductivity of grey crystalline Selenium varies greatly in accordance with the amount of light to which it is exposed, though the resistance is always high. This discovery, the great value of which is now realised, attracted comparatively little attention for some time. In recent years, however, it has been the subject of many elaborate researches by physicists on the Continent, in America, and notably in this country by Dr. Fournier d'Albe, of London. Investigations have been made to determine the laws governing the phenomena of photo-electric sensitiveness, to discover the physical or chemical basis of the action, and to find uses to which the effect could be put. I am indebted to Dr. Fournier d'Albe's published papers and notes for most of the facts relating to the properties of Selenium to which I refer to-night.

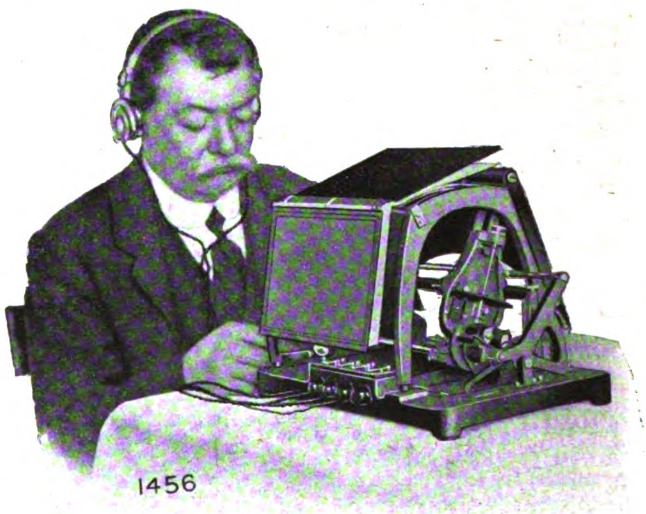

FIG. 1.—GENERAL VIEW: OPTOPHONE IN USE.

The full effect of light on the conductivity of grey Selenium is not attained instantaneously. If the electric conductivity across a bridge of grey Selenium connecting two conductors set, say, 1/50th in. apart, be determined in the dark and the bridge be then exposed to bright light, the conductivity will rise rapidly at first, then more and more slowly, till after about fifteen minutes' exposure it has risen about six-fold. On extinguishing the light, the conductivity again falls—rapidly at first, then more and more slowly—on the whole much more slowly than it rose on exposure to the light. But, though it takes a comparatively long time for the light to produce its maximum effect, a measurable and useful variation in the conductivity takes place in the periods of exposure and eclipse

as short as 1/100th or even 1/1,000th of a second, amounting to about 1/100th part of that attained on prolonged exposure. We are not at present concerned with the cause —or mechanism— of this change.

It may, however, be stated in passing that various theories of the action have been put forward. It has been suggested that it is due to the heating effect of the rays, but this has been completely disproved. Again, chemical action at the contact of the Selenium with the conductors has been suggested, but this again seems not to be a tenable hypothesis. Dr. Fournier d'Albe believes "the light action to be due to the liberation of electrons or other ions within the Selenium" and their re-combination in darkness.

quite beyond the power of the eye to detect. They promise to be of value in the detection of very faint light, such as that from stars too feebly luminous to be visible to the eye with the aid of any telescope. The automatic lighting up and extinguishing of light buoys, and even of lighthouses, has been proposed and some experiments have been made in this direction. In these cases the cumulative effect of the light over some comparatively long period—say, some seconds or even minutes—may be utilised.

But, as I have said, an effect appreciable by the aid of suitable instruments can be obtained in a small fraction of a second, so that instruments can be constructed that can detect pulsations of light of periods corresponding to those of the vibrations

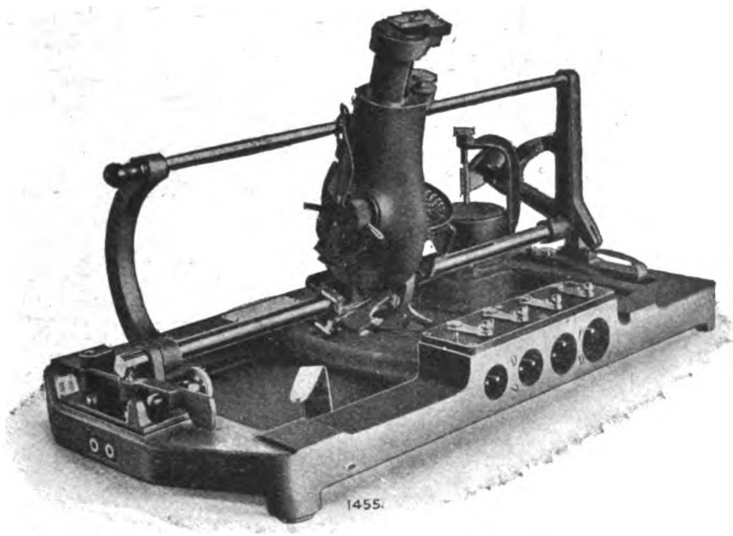

Fig. 2.—The Optophone with Book Rest Removed.

Since the discovery of this property of Selenium, it has been found that many substances have photo-electric sensitiveness to a small degree, but only one substance, viz., Stibnite or Antimonite, a natural Sulphide of Antimony, has yet been discovered to be, in this regard, at all comparable with grey Selenium.

Meantime, we are concerned with the *utilisation* of this very remarkable and, we may say, very fortunate property of Selenium. Already many uses have been found for light sensitive bridges. In photometry they afford a means of distinguishing quantitatively differences of illuminations

in audible sounds. A properly prepared Selenium bridge connected in series with a battery and a telephone receiver and exposed to illumination and eclipse alternating some hundreds of times per second, will cause corresponding pulsations of current through the telephone and produce audible sounds of corresponding pitch and quality. This is the basis of the Graham Bell Photophone, a wireless telephone by means of which speech can be conveyed, so to speak, along a beam of light from a transmitter to a Selenium receiver. It forms also the basis of the action of the Optophone. As other applications of the effect of rapidly

varying illumination on Selenium, one may mention its use in connection with multiplex telegraphy and photo-telegraphy.

Many forms of Selenium bridges (or cells, as they are sometimes less appropriately called) have been constructed for purposes of research, or as component parts of instruments of various kinds. I shall describe only the form that has been found, so far, to be best suited for use in the Optophone. The method of preparation is due to Dr. Fournier d'Albe.

If a bold pencil line be drawn on the surface of a small tablet of unglazed porcelain it will be found that the graphite (black lead) of the pencil line is quite a good electric conductor; that is to say, when the terminals of an electric battery of a few cells are connected to the two ends of the pencil line, a considerable current will flow through the thin film of graphite. Now, if a second pencil line be drawn on the porcelain, say 1/50th of an inch from the first line, and the terminals of the battery be connected one to each line, no appreciable current will flow—the bare porcelain of the gap forms a very perfect insulator between the conducting lines. If we now smear a thin layer of melted Selenium over the two lines and the intervening space, and, by suitable stoving, convert the Selenium from the vitreous into the grey crystalline state, it will be found that when the terminals of a battery are connected to the two pencil lines respectively, a small current will flow across the Selenium bridge, and the strength of the current will be found to be considerably greater when the Selenium is subjected to light than it is when it is in darkness. If, then, a telephone receiver be connected in series with the battery and the Selenium bridge, a current will pass through the telephone and the current will vary as the lighting of the tablet is varied. When flashes of light are thrown on to the tablet at a rate of 270 per second, the current will rise and fall at that rate and the telephone will sing out the note C (middle C of the piano). If the pulsations of the light be at half that frequency, *i.e.*, 135 per second, the telephone will sing out C an octave lower, and with 540 pulsations per second the C one octave higher, and so on. The telephone can thus be made to sing any tune by the proper succession of sets of pulsations of light applied to the Selenium. If, then, we can expose a Selenium bridge to a succession of pulsations of light corresponding in some way to the forms of letters as these are passed over in traversing a line of printing, each letter will be indicated by the telephone by a characteristic musical motif. This the mechanism of the Optophone does.

The Optophone is the invention of Dr. E. E. Fournier d'Albe. It was developed in 1912-1914 by successive steps, beginning with an instrument that enabled sightless persons to locate bright lights and shadows.

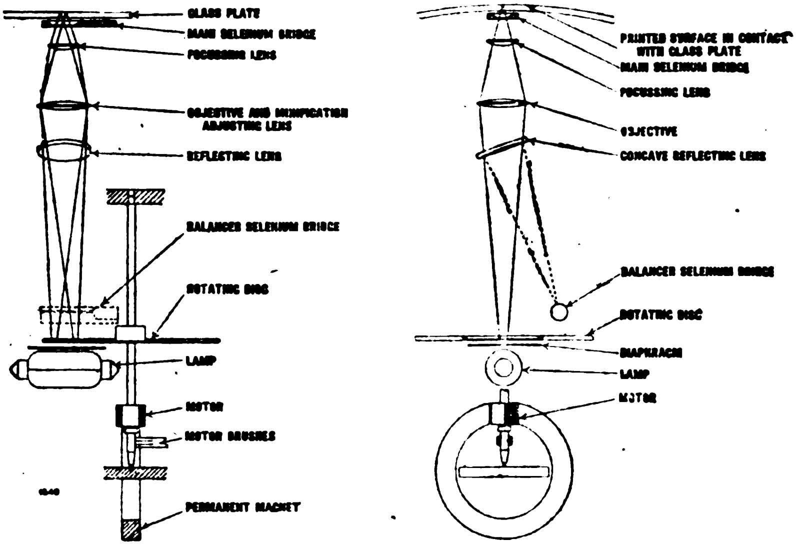

FIG. 3.—DIAGRAMMATIC ARRANGEMENT OF OPTOPHONE.

The second step was the production of an instrument by means of which transparent letters about 3in. high could be read. This first reading Optophone was exhibited at the British Association meeting at Birmingham in 1913. Dr. Fournier next attacked the much more difficult problem of reading ordinary printed matter by means of sounds, and in June, 1914, he produced the first type-reading Optophone. He constructed several instruments embodying most of the essentials of the present type, which, though of crude construction, proved so serviceable that a speed of reading of twelve words per minute was attained by one of his blind pupils—Miss Jameson—after about 20 hours of instruction. Dr. Fournier d'Albe's work was thereafter interrupted by the war. The instrument came into the hands of Messrs. Barr and Stroud, Limited, about two-and-a-half years ago. Much time and thought have been expended on its development and a great deal of experimental work has been carried out, leading to many improvements in the design. Already with the first of the new instruments completed Miss Jameson has increased her speed of reading to about twenty-five words per minute, and all indications point to a much greater speed being attained.

In the Optophone the printed page to be read is placed face downwards on a glass plate supported on a suitable stand. Beneath the plate is placed a tablet of porcelain pierced with an aperture to permit the passage of a small pencil of light upwards and so through the glass on to the paper. The upper surface of the tablet, around the aperture, is prepared as a sensitive Selenium bridge and connected up to a battery and a telephone in the manner described. The bridge receives only light reflected from the page. The illumination of the bridge is thus much greater when the pencil of light falls on a white part of the page than it is when the light falls on a black part, *i.e.*, on a portion of a letter. If the light in such a pencil is pulsating at the rate of 270 flashes per second, the telephone will receive a pulsating current and sound the note C so long as the pencil of light falls on white paper, but will be practically silent when the light falls on black. Thus, if the paper be moved along—or the pencil of light be moved over the paper—the presence of black markings will be indicated, but the different letters will not be distinguishable.

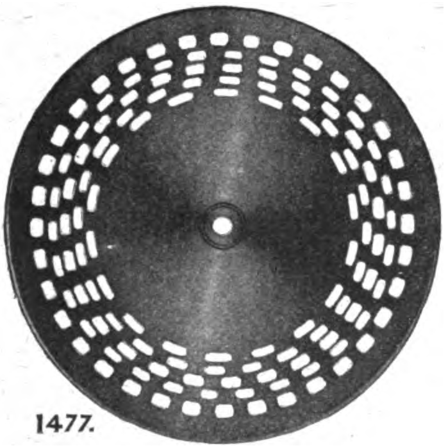

Fig. 4.—Rotating Disc.

The light used in the Optophones exhibited is that from a small straight filament electric lamp (an ordinary "festoon" lamp). In one of these instruments the lamp is placed radially under a thin brass disc 3in. in diameter. In the second example the lamp is so arranged in conjunction with a reflecting prism and cylindrical lenses that an image of the filament is produced in the plane of the disc. The disc is perforated with small holes arranged in five or more circles (siren disc fashion) near its edge. The disc is kept in rapid rotation by means of a tiny magneto-electric motor driven by current from one or two small secondary cells.

In the first of these instruments, an opaque diaphragm, having a narrow slot

lying radially under the disc, is mounted between the lamp and the disc, or above the disc.

In the second instrument in which an image of the filament is formed in the plane of the disc, the diaphragm is not required. Above the disc there is an optical system which throws on to the paper an image of the holes in the disc as they pass the slot in the diaphragm, or in the second case an image of the filament image is seen through the holes in the disc.

By this means the light that falls on the printed matter forms five or more bright spots, forming what we call the "scala." Each spot is pulsating at a rate corresponding to the number of holes in the circle of perforations to which it belongs, multipled by the number of revolutions per second of the disc. Thus, if there be 18 holes in the innermost circle, 24, 27, 30 and 36, in the other circles respectively, and the disc makes 540 divided by 24—about 22—revolutions per second, the second circle of holes will produce 540 pulsations of light—corresponding to the note C′. The numbers of holes given above are in proportion to the vibrations in the notes G, C′, D′, E′, G′ (soh, doh, ray, me, soh). A change in the speed of rotation of the disc, of course, alters the pitch of the notes, but the intervals remain unaltered. A faster or slower rotation of the disc than that supposed only alters the key. Too high or too low a pitch lessens the audibility of the note for a given intensity of light.

The optical system used to produce the image of the holes has a variable minification, so that the length occupied by the scala of five spots may be made equal to the height of the letters to be read, the range of adjustment covering the various sizes of type employed in ordinary printing. The system is so designed that the plane in which the image of the holes in the disc is formed is little altered by a change in the minification, but the upper lens of the combination can be moved slightly to get a sharp image whatever the minification. The spot corresponding to low G is caused to fall on the lowest points of such letters as j, p, y, etc., the high G falling on the tops of capitals and of the high letters. The three intermediate spots cover the height of the short letters.

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Fig. 5.—Scala Passing over Printed Letters.

Provision was made in the first Optophone for moving the book over the Selenium tablet by means of a hand-driven gear. In the instruments now being constructed the glass plate is curved and a "tracer" carrying the lamp, disc, and optical system, is pivoted about the axis of the curve and swings so that the spots of light travel along the line of printing, the book remaining stationary. An automatic gear controlled by a governor has been introduced to move

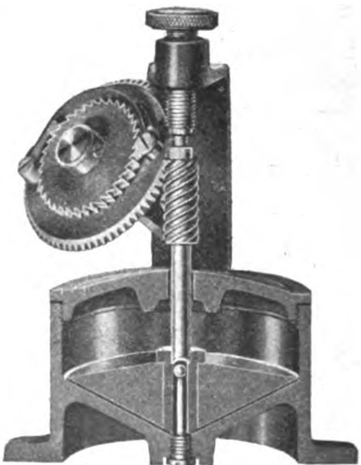

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Fig. 6.—Sectional View of Governor.

the tracer at any desired constant speed. For beginners the governor can be set so that the motion is slow and the speed can be increased as proficiency is attained.

If all the spots of light fall on white paper —say, the space between two words—all the notes will be sounded together in the telephone, producing a discord. Now, if the "scala" passes over the letter V the note G′ will first be silenced, then E′, D′, C′, D′, G′, in succession. It will be evident then that each letter will alter the succession of sounds in a different manner. The "sound alphabet" so produced has to be learned. The arrangement described constitutes what may be called a "white-sounding" Optophone.

One of the improvements introduced by Messrs. Barr and Stroud, Ltd., is the modification of the instrument so as to make it "black-sounding." In this form white paper is represented by silence (more or less complete) and notes are sounded as the "scala" comes over black markings. reflecting aside a small part of the light on its way from the disc to the paper and connecting this bridge to the telephone and a battery in such a manner that the current traversing in the balancer bridge acts in the reverse direction in the telephone to that of currents from the main Selenium bridge. One battery is used and the two Selenium bridges are connected one to each end of the battery, and both through the telephone to a selected intermediate junction of the battery, in the manner shewn on the slide. The balancer thus tends to cause the telephone to sound all the notes continuously and the Selenium bridge that receives the light reflected from the paper annuls the effect on the telephone in respect to any note when the spot of light corresponding to that note falls upon white paper. Provision is made for adjusting the division of the total voltage of the battery between the two bridges and also for varying the amount of light that falls on the balancer

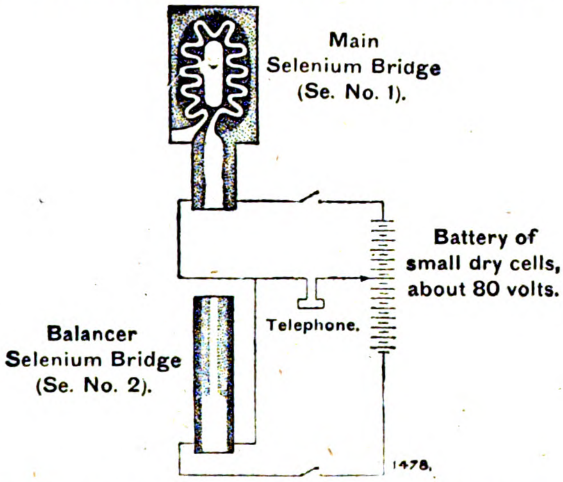


FIG. 7.—DIAGRAM OF SELENIUM BRIDGE CONNECTIONS.

With this form of Optophone—other things being as described—the letter capital V is represented by the motif G′, E′, D′, C′, D′, E′, G′, sung more or less rapidly, according to the speed of reading for which the instrument is set. The letter A is represented by the same notes, but in ascending and then descending order, with the note E′ or D′ continuing to sound as the corresponding spot of light passes along the horizontal line. The letter small o is represented by the motif D′, E′C′, D′, and so on.

The "black-sounding" is obtained by providing a second Selenium bridge, which is called the "balancer," illuminated by bridge so that when the whole scala falls on white paper the telephone is silent or so very nearly silent that the continuous sound does not interfere at all with the motifs representing the letters to be read.

An adjustable and reversible friction gear has been devised for moving the tracer down the page, a line space at a time, or up the page one line space if desired for re-reading a line.

In the process of reading, when the tracer has passed to the end of one line, the line changer is operated and the tracer swung over, when it automatically traverses the next line, and so on.

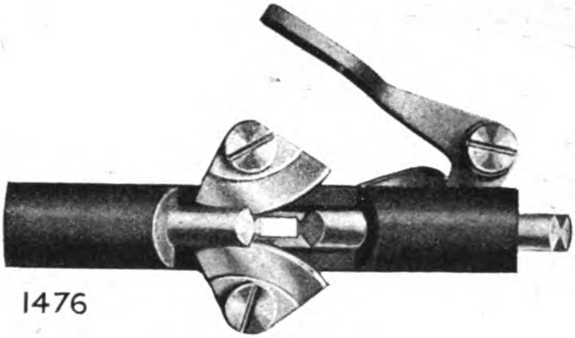
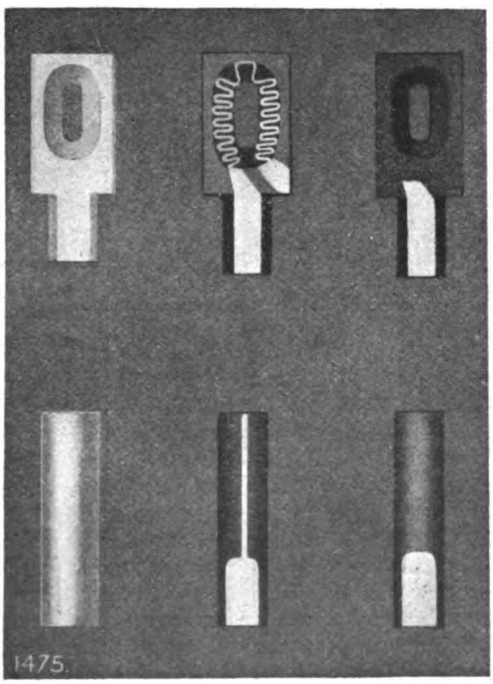


FIG. 8.—LINE CHANGING GEAR.

It will be observed that Optophone reading is analogous to reading by sight through a narrow slit in an opaque screen moved over the letters. It would be extremely difficult for the eye to recognise at all rapidly the significance of a set of narrow black markings successively exposed. We are not accustomed to piece together such marks successively exhibited. We are, however, quite accustomed to piece together a succession of sounds, as we do every time we listen to a piece of music or, indeed, to spoken words.

I have illustrated the behaviour of the Optophone by reference to the motifs corresponding to the letters V, A and o. These motifs are easily represented by symbols and the connection of the motif with the form of the letter is readily recognised from the succession of notes in the motif.

It is not to be supposed, however, that Optophone reading will consist in analysing the sound motifs so as to identify the forms of the letters indicated. That would be hopelessly slow. The motif for each letter will be recognised as a whole, and later in the reader's practice the more extended motifs for syllables, and even words, will become familiar to his ear. In reading by sight,



PRIMARY SEL. CELLS.

BALANCER SEL. CELLS.

FIG. 9.—SELENIUM CELLS (full size) AS USED IN OPTOPHONE.

we do not think of the similarity and difference between such letters as e and c, nor indeed do we think of the difference of the sounds when we hear the names of these two letters spoken. An Optophone reader will come to recognise words as readily as a telegraph operator interprets a succession of clicks on the Morse Code. He will treat the motifs produced by the Optophone as words in a new language, which he will translate into the spoken tongue as they are uttered. The great rapidity that has been attained by hundreds of readers of Morse sounds encourages the hope that equal or greater speed in Optophone reading will be attained with practice. In proof of this, I may state that Miss Jameson, in her recent trials of one of the new Optophones, finds that she can read more easily at 25 words per minute than at 10 words per minute.

Hand-writing—of less than copperplate quality—one may expect will always be very difficult to decipher and may be left out of consideration, but the reading of type-written matter should be quite within the capacity of an Optophone reader, and now that many sightless persons are expert typists, the Optophone should greatly extend the fields of employment open to them.

The value of a new invention such as this cannot at first be fully realised. Some of those here present may remember, as I do, that in his Presidential Address to Section A of the British Association at the Glasgow meeting in 1876, Sir William Thomson (Lord Kelvin) startled the people of this country when he exhibited a crude little piece of apparatus and announced that in America, from which country he had just returned, he had heard "just such a little disc armature" as that which he held in his hand repeating a sentence that was being spoken into another instrument at a considerable distance away, the only connection being a couple of wires. The Graham Bell telephone, of which that was a first crude example, has since then vastly altered the conditions of life over the whole world and the developments from that small beginning show no sign of coming to an end. If anyone here should think that the Optophone which I am able to exhibit to-night leaves a great deal yet to be desired in the fulfilment of the purpose for which it has been devised, I would ask him to remember that the instrument is still in its infancy. I have no doubt that the development of the Optophone will be carried forward, if not by those at present working upon it, by others in the future, to a perfection that we cannot yet foresee.

It is natural to suggest that an important advance would be the construction of a loud speaking Optophone, but fuller consideration modifies one's first impressions of the utility of such a development. Some attempts have already been made to intensify the currents available for the telephone by the use of thermionic valves and other accessories, but it is to be remembered that any instrument that is to be used by the blind should be kept as simple in its construction and manipulation as possible. The present instrument can operate two telephones—perhaps more than two—quite successfully, giving sounds amply loud enough to be clearly heard. It might occasionally be of advantage to be able to operate, say, a dozen telephone receivers simultaneously, but probably little would be gained even by an advancement in this direction. When two people read by sight from one book simultaneously, we know that one may wish to turn the page long before the other has got to the foot of it, and with an Optophone working continuously, one listener cannot refer back to a word that has not been caught on the first passage, as a sight reader would glance back over a line that was not understood. A speed of operation that would suit one reader would make the whole quite incomprehensible to another of less proficiency. Should a number of blind persons wish to learn what is contained, say, in a newspaper article, it would be more advantageous for one to read and to translate to the others—as would be done with the Braille system—than for all to attempt to listen to the Optophone notes.

For teaching purposes a "class sounder," such as you have heard this evening, may be used with advantage for the preliminary training of a group of pupils. Or, again, gramophone records could be used.

A word or two may be said with regard to the limitations of Optophone reading. We cannot expect to enable a sightless person to glance rapidly over the pages of a newspaper, as we who have sight would do, and select the passages that may be of interest; nor can we expect a blind person to turn rapidly over the pages of

a book and find a specified page. Again, when the desired page is found, it will not be easy to find a particular passage without reading word by word from the beginning of the page. But, apart from such obvious disabilities, the instrument should open up quite a new field of interest and instruction to the blind in enabling them to study books and magazines that are at present closed to them. I have no doubt that thousands of those who have the misfortune to have been born blind or who have lost their sight in the services of their country or otherwise will be profoundly grateful to Dr. Fournier d'Albe for this beautiful invention which brings within their reach new sources of interest, instruction and enjoyment, and which in many cases will greatly extend their opportunities and qualifications for useful and profitable employment.

[The paper was illustrated by a number of lantern slides, and a demonstration was given by Miss Green, a totally blind lady, of reading by means of the optophone. At the conclusion of the paper, a demonstration was given on the optophone, with the addition of an amplifier, kindly provided by the Chairman, by means of which the audience clearly heard the various musical notes corresponding to the print.]

DISCUSSION.

The CHAIRMAN (Mr. Alan A. Campbell Swinton, F.R.S.), in opening the discussion, said the author had mentioned the advantages and disadvantages of the optophone as compared with Braille and Moon type, and that reminded him of a story he had been told a few days ago about an elderly gentleman who was losing his sight and therefore was learning to read Braille. He said the great advantage of Braille was that in cold weather one could read in bed and still keep one's hands under the bedclothes. He was afraid the optophone was not perhaps adapted for that! He was also reminded by the author's remarks of an interview he had some years ago with Prof. Graham Bell, the inventor of the telephone. Prof. Bell said to him on that occasion: "You know people think that I am an electrician, but I am not. On the other hand, one of my friends said I could not be an electrician, because if I had been I should have known beforehand that my telephone could not work." He thought perhaps that remark had some bearing upon Dr. Fournier d'Albe's wonderful invention, because he did not think any electrician would have believed it possible to make the optophone work—certainly not to make it work in the wonderful way that had been achieved by the author.

Mr. HENRY STAINSBY (Secretary-General of the National Institute for the Blind) said that since the year 1914 he had been very much interested in the optophone. It was in that year, just before the outbreak of the war, that Dr. Fournier d'Albe gave an exhibition of the optophone at a very important International Conference on the blind, which was held at the Church House, Westminster. As the author said, the subject remained in abeyance for a long period, in consequence of the war, but had now been revived, and the Institute with which he was connected had taken an active part in testing the apparatus and in affording facilities for instruction in its use. At the request of the Inventions and Research Committee of the Institute he had undertaken to make the tests, but they were not yet completed, so he was not in a position to give the results of them, and the remarks he was about to make were, therefore, personal and not official. He had come to the conclusion that the optophone had not yet had a fair test. The human material that had been used had not been of the right kind. People were taught to read in the ordinary way very early in life, and he was convinced that if the optophone was to be properly tested, the tests should be carried out in a school amongst young children, and should extend over a long period. If that plan was adopted he was very much inclined to think that the results would surpass general expectations. The author had mentioned the Braille and Moon type, in both of which types the National Institute for the Blind published the bulk of the literature issued for the blind in the whole world. The Moon type did not occupy quite so much space as the author thought; indeed, not quite half as much; nevertheless, both the Braille and the Moon types were extremely bulky. The great advantage of the Optophone was that it put the literature of the whole world at the command of the blind, whereas tactile print gave them a very limited field indeed. Therefore, if the Optophone proved a success, as everyone sincerely hoped it would, a great deal more reading matter would be put at the command of the blind than was at present available to them.

DR. E. E. FOURNIER D'ALBE said he was extremely flattered and touched by the way the author had referred to his work in connection with the optophone. He did not think anyone realised the immense labour and care which the author had bestowed upon the instrument, but personally, after his experience in the early stages, he certainly realised that a great amount of work had been done in improving his original model so as to produce a marketable commodity which was portable and reasonably reliable and safe for a blind person to use. He would like to call attention to the silent automatic drive which had been one

of the great problems in connection with the optophone. A drive was required which brought out the rhythm of the letters, as that helped the blind a great deal. It was very greatly to Dr. Barr's credit to have devised that exceedingly good automatic governor which he showed upon the screen and which certainly solved the problem in an absolutely complete way. He thought he was right in saying that that governor had been invented for the optophone and was therefore a direct contribution not only to that instrument but to the science of mechanism generally. With regard to the wonderful discs the author had shown, which were produced at the works of Messrs. Barr & Stroud, it would have been noticed that the perforations were square, and that had naturally added considerably to the clearness and loudness of the notes. It was a matter that was quite beyond his own mechanical ability. The author had made one or two comparisons between black-sounding and white-sounding instruments. As the author had mentioned, the illustration he had given on the mechanical model was not quite fair to either method. As a matter of fact, the sound was of course exceedingly rapid; in fact, a tune played by the letters would be best realised by imagining "God save the King" played right through in about half a second. The musical character would be entirely lost; the result would be simply a medley of sound which one would probably have some difficulty in recognising as the National Anthem. That was the kind of music that had to be dealt with in optophone reading. Personally, he had still a slight preference for the white sounding instrument, which was the original method he used, but he quite saw that for beginners, at all events, the black sounding machine might be better. It was much more graphic; the letters spoke for themselves and almost drew their own shape, and probably it would be very much pleasanter to learn by a black sounding machine. He was convinced that when it came to really fast reading the two methods would be practically equivalent: in fact, in very rapid reading they sounded very nearly alike. Messrs. Barr & Stroud had fortunately been able to put an instrument before the public which could be used by either method, so that each one could choose the method that suited him best. He wished to draw attention to the fact that Miss Green, in using the instrument, did the entire manipulation of it herself. She took the book at a given page, raised the book rest and inserted the book, and very quickly found the first line. One of the problems was to get the lines straight; the tracer must go right over the line. Naturally, when one line was straight the whole of the rest of the lines on the page would be straight in any well-printed book. The instrument was designed for manipulation by blind persons, who were naturally rather less able to cope with a complicated mechanism than other people were. So far as present experience had gone, it had been found that it took about 20 hours of instruction before one could begin to read at all, and one then read at a very slow rate, about one word a minute. There seemed to be a steady graduation of improvement; with every 20 hours spent in practice a learner added another word a minute to his speed, and after 100 hours' practice, he could read at a speed of about five words a minute. Miss Green had had about 150 hours' practice, and her speed was about seven or eight words a minute, so long as she kept to the same kind of type. There was an infinite variety of type and any little difference in the design of the type made a difference, so that a fair test was one in which only one kind of type was used. There were such things as typescript, newspaper type, and type in various languages, which were all different. He was glad to hear from the author that Miss Jameson was able to read French type. That of course meant that she had had to practise with the accented vowels, and it proved that when once the alphabet of any language was acquired one could read that language, provided, of course, that one knew it. One of the claims made on behalf of the optophone was that it was an absolutely international instrument. He might say that Chinese, Arabic, Hebrew, Sanskrit, and all the alphabets based on the Sanskrit, were very much easier to read than Roman type, which was one of the worst types that could be chosen for this purpose. Sometimes comparisons were made between the optophone and the Morse code, but in Morse reading only rhythm was utilised and everything was on the same note, so that the optophone had an immense advantage in that respect. It operated not only by rhythm but also by pitch, so that the real comparison was not with Morse reading but with ordinary human speech, which was the rapid succession of ordered notes succeeding each other with enormous rapidity, but which could be actually analysed at a speed of 200 words a minute by the average human ear. That was really a very important parallel, which put almost boundless hopes in front of those optophone readers who were sufficiently persevering to give the instrument a proper trial. There had naturally been quite a number of attempts to improve on the optophone. One such attempt was made in America, but that was based upon entirely wrong principles, as one had to wait for the full effect of the light action on the selenium instead of using the flash effect. That put the American instrument out of court as a rival of the English one. One could not afford to wait for the full effect to take place, for then one letter would be blurred into another and rapid reading would be entirely out of the question. An attempt had been made in Germany to produce an instrument

that would give a tactile sensation and would therefore be, so to speak, an intermediate thing between Braille reading and optophone reading. That, however, had the same fundamental defect as the American instrument, as one had to wait for the full effect to take place. He thought it could be fairly claimed that the optophone was a British invention from beginning to end. No other nation was ahead of this country in regard to the optophone, or even anywhere within sight of it. He wished to say a few words about the great pleasure it had been to him to conduct the class arranged by Sir Arthur Pearson at the National Institute for the Blind. That class was still in existence and had been referred to by Mr. Stainsby in very kind words. He would like to take the present opportunity of placing on record his very profound sense of gratitude for the great facilities which had been afforded to him in that connection, and also for Mr. Stainsby's personal kindness to him. In the course of conducting the class, certain improvements had been devised which had made the manipulation of the instrument considerably easier. It had given him much pleasure to attend the present meeting, and he certainly could not have asked for a kinder or more flattering exponent of the principles of the optophone than Dr. Barr.

MR. P. M. EVANS, LL.D. (Clerk to the Cloth workers' Company), said he had listened with the greatest interest to the author's very able paper and had been delighted at the possibilities it seemed to hold out. For a great many years he had been keenly interested in the welfare of the blind, partly in connection with his office as Clerk to the Cloth-workers' Company, which administered large trust sums in pensions for the blind, and partly in connection with his work for the Metropolitan and adjacent Counties' Association for the Blind. For the last three years he had been sitting on a Committee of which Mr. Stainsby was also a member, which had been considering from time to time what recommendations should be made to the Ministry of Health for the improvement of the welfare of the blind. One of the special points the Committee had considered was how the means of occupation and recreation of the blind, particularly in the way of reading, could be improved. His Association was greatly indebted to the National Institute for the Blind for the great work it had done in printing books in Braille, and was also much indebted to the National Library for the Blind for similar work and for the work which they had done in distributing those books and making them accessible as far as possible to all the people who required them. It had occurred to him while listening to the paper that the optophone would provide a great opportunity of supplementing that work, and there now seemed to be a prospect of making accessible to the blind books that were not at present printed for them, as well as such things as newspaper articles and so on. If that could be done a great work would have been accomplished and blind people would have the facilities for reading which they had so long been wanting. He felt that those interested in the blind were very much indebted to the author for his paper, and that there were great possibilities in front of them.

The CHAIRMAN, in proposing a very hearty vote of thanks to the author for his paper, which had been admirably illustrated, and would be well worth reading when it was published in the Journal of the Society, said the subject of the paper was one which everybody must feel was of great importance. Any invention that could help to alleviate the restrictions imposed upon blind people would be welcomed by all.

THE HON. SIR CHARLES A. PARSONS, K.C.B., F.R.S., in seconding the vote of thanks, said the optophone embodied more physical inventions and properties of matter than almost any instrument he had ever seen. It provided a beautiful means of linking the musical gamut with the altitude of the letters. A musician could, by reading music, appreciate its beauty and harmony from very long experience beginning at an early age, and in the optophone there was the transfer of letters into the altitude of the "doh, ray, me, soh" gamut. He remembered once hearing that some Japanese were buried in a graveyard at Newcastle-on-Tyne, and they had a tombstone with an inscription in Japanese letters, and two pitmen happened to go by it one day. One asked the other if he could read it, and he replied: "No, but if I had my fiddle I might play it!" The optophone contained some most beautiful mechanical devices. The whole mechanism, in fact, was perfectly wonderful, and the governor was quite original. He was sure everyone present was very much indebted to the author for explaining the instrument so very lucidly. He thought the principles involved in it were probably capable of very great enlargement and elaboration in the future, and it might be made to reproduce music in the same way as it read printing.

MR. ARCHIBALD BARR, LL.D., D.Sc., in reply, said it had been a great pleasure to him to have interested those present in the optophone, which he thought had considerable possibilities before it. Dr. Fournier d'Albe had referred to the perforations on the disc. That disc was made by the very simple process of drawing a picture of the disc, photographing it upon the metal, and etching it through. In that way it had been possible to make the disc exceedingly true, of a very thin light material, and at a reasonable cost. Dr. Fournier d'Albe had also said that Miss Jameson had been able to read French by the optophone, and he might mention that Miss Jameson told him that

she thought French characters were more easy to read than English, on account of the accents. She found the accents an advantage rather than a disadvantage. With regard to Miss Green's demonstration, the speed at which she had read on the present occasion must not be taken as her best speed, partly on account of the circumstances and also for the reason that whereas with Braille one could speak and feel at the same time, one could hardly listen and speak at the same time, as was necessary in reading aloud with the optophone. In connection with the remarks Sir Charles Parsons had made about the automatic gear controlled by a governor, he might say that the instrument had a little spring which had very considerable difference of driving power, and the tracer had very considerable weight. The arrangement was such, however, that when the spring was strong the tracer had to be raised and when the spring became weaker towards the end the tracer helped it. The result was that a uniform torque was obtained, which caused the instrument to be driven at a uniform speed.

The meeting then terminated.

CORRESPONDENCE.

SCIENCE AND THE INVESTIGATION OF CRIME.

In the course of the discussion on the above-mentioned paper, Sir Basil Thomson referred to Henry Fielding's successful magisterial activities at Bow Street in 1752.

May I remark that some form of rudimentary hand-comparison appears to have been resorted to in Fielding's day in the detection of crime, for in *Tom Jones* (book x, ch. 1) he writes:—"For want of judgment vulgar spectators of plays very often do great injustice in the theatre, where I have sometimes known a poet in danger of being convicted as a thief, upon much worse evidence than the resemblance of hands hath been held to be in the law." I have not succeeded in finding any reference to this mode of identification in Matthew Hale's *History of the Pleas of the Crown*.

J. Paul de Castro.

KEY INDUSTRIES.

The importance of key industries to the nation in times such as we have recently passed through, is so fully recognised that every endeavour ought to be made to establish or promote not only those industries whose products are directly applicable to the purposes of war, but also those in which the workers require skill and training which will enable them easily to adapt themselves to the production of war munitions in cases of national emergency.

It appears to us that this end may be in many cases successfully attained by deciding upon specific articles the production of which is desirable in this country, such articles being at present not produced here at all, or only in qualities inferior to the foreign product.

This being settled, an import duty should be placed on the articles in question, one portion of the duty being allocated to revenue account and the other set aside to form a fund for the encouragement of firms willing to install the plant and enter upon the research necessary to successful manufacture of the article. There would then be a number of growing funds available, each applicable only to a specific article.

The method of dealing with the funds could be decided by a small committee or trustees for each fund.

A case in point is the manufacture of photographic carbons for arc lamps. The German carbon has undoubted advantages over all others, and even under a heavy duty it is profitable to the user to purchase this for photographic work. A close approximation to the German article is made in America, but for photographic purposes the British carbon is undoubtedly inferior.

Arc lamp carbons for searchlights and photographic and plan copying work are very essential in war time, and should be manufactured here.

Herein lies a simple case for research, which, if carried through carefully should result in the production of superior photographic carbon, improvement in the ordinary illuminating carbons, and an ultimate reduction in cost of manufacturing and selling prices.

For B. J. Hall & Co., Ltd.

B. J. Hall,
Chairman.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at 8 p.m., unless otherwise announced:—

May 4, at 4.30 p.m.—Sir Geoffrey G. Butler, K.B.E., Director, British Bureau of Information, U.S.A., 1917-19, and Member of Executive Committee, Reunion of British War Mission to the United States, "Anglo-American Relations: a Personal Impression." The Right Hon. Viscount Bryce, O.M., G.C.V.O., D.C.L., F.R.S., in the Chair.

May 11, at 6 p.m.—Alfred E. Hayes, General Secretary, English Language Union, "Phonoscript: A New Method in the Pho-

netic Teaching of English Pronunciation." A Demonstration will be given by Scholars from the Infants' Department of an Elementary School.

MAY 25.—DR. C. M. WILSON, "The War and Industrial Peace: an Analysis of Industrial Unrest."

MONDAY, MAY 30.—SIR KENNETH WELDON GOADBY, K.B.E., Medical Referee for Industrial Poisoning, County of London, "Immunity and Industrial Disease."

INDIAN SECTION.

At 4.30 p.m.

TUESDAY, MAY 3.—WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India." SIR ROBERT W. CARLYLE, K.C.S.I., C.I.E., late Member of the Government of India, in the Chair.

FRIDAY, JUNE 10.—SIR GEORGE SEYMOUR CURTIS, K.C.S.I., Member of the Executive Council, Bombay, "The Development of Bombay."

INDIAN AND COLONIAL SECTIONS.
(Joint Meeting.)

At 4.30 p.m.

FRIDAY, MAY 27.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, MAY 2..Wireless Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m.

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev. J. Gosset-Tanner, "The Tripartite Nature of Man."

Farmers' Club, 2, Whitehall Court, Whitehall Place, S.W., 4 p.m. Prof. T. Wibberley, "The Wibberley System of Farming."

Royal Institution, Albemarle Street, W., 5 p.m. Annual Meeting.

Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. A. S. E. Ackermann, "The physical Properties of Clay."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. (1) Dr. R. Lessing, "Fractional Distillation with Contact Ring Still-Heads." (2) Mr. N. E. Rambush, "Thermal Losses in the Gas Producer Process."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Annual General Meeting.

Electrical Engineers, Institution of (Western Centre), at the Merchant Venturers' Technical College, Bristol, 7 p.m. Presidential Address by Mr. Le B. Atkinson.

TUESDAY, MAY 3..Royal Institution, Albemarle Street, W., 3 p.m. Prof. A. Keith, "Darwin's Theory of Man's Origin (in the light of present-day evidence). (Lecture III.)

Alpine Club, 23, Savile Row, W., 8.30 p.m.

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. H. S. Watkins, "Colour Photography."

Anthropological Institute, at the Royal Society, Burlington House, W., 8.15 p.m. Mr. J. R. Moir, "An Early Chilean Palaeolithic Workshop Site in the Pliocene Forest Bed of Cromer, Norfolk."

WEDNESDAY, MAY 4..Geological Society, Burlington House, W., 5.30 p.m.

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m. (1) Messrs. F. G. H. Tate and J. W. Pooley, "Detection and Estimation of Illipé Nut Fat used as a Substitute for Cocoa Butter." (2) Mr. G. W. M. Williams, "Notes and Demonstration on Apparatus for determining Hydrogen in concentration." (3) Mr. E. Paul, "A Note on the Oil of Oats." (4) Mr. H. Atkinson, "Estimation of Potassium in Presence of Sodium, Magnesium, Sulphates and Phosphates."

Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Prof. T. Turner, "The Casting of Metals."

Oriental Studies, School of, Finsbury Circus, E.C. Miss A. Werner, "European Expansion in Africa." Lecture II.: "The Rise of British Rule in South Africa."

Royal Archaeological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m.

THURSDAY, MAY 5..Fine Art Trade Guild, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 7 p.m.

Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W., 10 a.m. Annual Meeting. (1) Mr. H. Brearley, "The Welding of Steel in relation to the occurrence of Pipe Blow Holes and Segregates in Ingots." (2) Mr. J. E. Stead, "Solid Solution of Oxygen in Iron." (3) Mr. H. T. Ringrose, "Scientific Control of Combustion." (4) Mr. J. E. Fletcher, "Open-hearth and other Slags: their Composition and Graphic Methods for Determining their Constitution." (5) Mr. S. H. Fowles, "Notes on the Cleaning of Blast-Furnace Gas." (6) Mr. J. Newton Friend, "The Protection of Iron with Paint against Atmospheric Corrosion."

Royal Society, Burlington House, W., 4.30 p.m. (Croonian Lecture.) Dr. H. Head, "Release of Function in the Nervous System."

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace Road, S.W., 6 p.m. Miss F. E. Webb, "Individual Training in the School."

Automobile Engineers, Institution of (Informal Meeting), at the Chamber of Commerce, Birmingham, 7 p.m. Demonstration of Labour Saving Devices in the use of Tyres, Detachable Wheels, etc.

Royal Institution, Albemarle Street, W., 3 p.m. Dr. C. S. Myers, "Psychological Studies: Localisation of Sound." (Lecture I.)

British Architects, Royal Institute of, 9, Conduit Street, W., 5 p.m. Mr. F. C. Eden, "Architecture and Travel."

FRIDAY, MAY 6..Transport, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. D. J. Owen, "Docks and Harbours, General Structural Lay-out Systems of Control, Operations and Charges."

Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W., 10 a.m. Annual Meeting continued. (1) Mr. S. N. Brayshaw, "The Prevention of Hardening Cracks, and the Effect of Controlling the Recalescence of a Tungsten Tool Steel." (2) Messrs. K. Honda, T. Matsushita and S. Idei, "On the Cause of Quenching Cracks." (3) Mr. W. E. Hughes, "Slip Lines and Twinning in Electro-deposited Iron." (4) Mr. J. H. Whiteley, "Cupric Etching Effects Produced by Phosphorus and Oxygen in Iron." (5) Mr. A. Westgren, "Roentgen Spectographic Investigations of Iron and Steel." (6) Mr. T. E. Rooney, "Comparison of Different Methods of Estimating Sulphur in Steel."

Royal Institution, Albemarle Street, W., 9 p.m. Sir Robert Robertson, "War Developments of Explosives."

Philosophical Society, University College, W.C., 8 p.m. Anniversary Meeting. Prof. C. E. Spearman, "Psychology and Philology."

SATURDAY, MAY 7..Royal Institution, Albemarle Street, W., 3 p.m. Prof. E. C. C. Baly, "Chemical Reaction." (Lecture I.)

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FRIDAY, MAY 6, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES

NEXT WEEK.

WEDNESDAY, MAY 11TH, at 6 p.m. (Ordinary Meeting.) ALFRED E. HAYES, General Secretary, English Language Union, "Phonoscript: A New Method in the Phonetic Teaching of English Pronunciation." GEORGE E. MACLEAN, Ph.D., LL.D., Director of the British Division of the American University Union in Europe, in the Chair.

[A demonstration will be given by scholars from the Infants' Department of a London Elementary School.]

NINETEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 27th, 1921; SIR THOMAS H. MIDDLETON, K.B.E., C.B., LL.D., Member of the Development Commission, in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Ahmed, S. A., Howrah, Bengal, India.
Culley, Alexander, London.
Hayashi, Kunizo, Tokyo, Japan.
Livermore, James Edward, Manchester.
Purse, Ben, London.

A paper on "The British Research Association for the Woollen and Worsted Industries," was read by SIR JAMES P. HINCHLIFFE, Chairman of the Association.

The paper and discussion will be published in a subsequent number of the *Journal.*

INDIAN SECTION.

TUESDAY, MAY 3RD, 1921; SIR ROBERT W. CARLYLE, K.C.S.I., C.I.E., in the chair. A paper by Mr. WILLIAM RAITT, F.C.S., Cellulose Expert to the Government of India, on "Paper Pulp Supplies from India," was read, in the author's absence in India, by Mr. R. W. Sindall, F.C.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

SEVENTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 13TH, 1921.

SIR ARTHUR DUCKHAM, K.C.B., M.Inst. C.E., in the Chair.

THE CHAIRMAN, in introducing Prof. Armstrong, the author of the paper to be read that evening, said that he had an intimate knowledge of the subject with which he would deal and could speak with authority on it from both the technical and the practical points of view. Another great advantage was that Prof. Armstrong was not biassed on the subject but was trying to arrive at the truth in regard to a matter which he had very much at heart.

The following paper was then read:—

RELATIVITY AND THE PROBLEMS OF COAL. LOW TEMPERATURE CARBONISATION AND SMOKELESS FUEL.

By PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S.

He held that the state of England, notwithstanding the superficies of a material prosperity, was one of impending doom, unless it were timely arrested by those who were in high places.

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Europe is not happy. Amid its false excitement, its bustling invention and its endless toil, a profound melancholy broods over its spirit and groans at its heart. In vain they

baptize their tumult by the name of progress; the whisper of a demon is always asking them: "Progress, from whence and to where?"

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The European talks of progress, because, by an ingenious application of semi-scientific acquirement, he has established a society which has mistaken comfort for civilisation.
Disraeli: "Tancred."

The aspect of the years that approach us is as solemn as it is full of mystery; and the weight of evil against which we have to contend is increasing like the letting out of water.
Ruskin: "Seven Lamps of Architecture."

These citations are proof that shrewd observers, if not prophets, were abroad in our country so recently as the middle of last century. To-day we are a house entirely divided against itself: we were never more so, never so lacking in sense of proportion and particularly in the faculty of proportionate judgment. God and the Devil seem to be ever present in each one of us and the Devil usually leads; after all, these two conceptions are but the poetic embodiment in single words of the sum of human experience.

Having made unparalleled sacrifices, with that inconsequent obstinacy which is our characteristic, we are now showing unparalleled and suicidal selfishness. Leaders with ideals, gifted with sanity and some breadth of outlook, alive to the possibilities and competent to grasp them, are nowhere to be found. We no longer allow such to arise. The race of teachers is at its last gasp of incompetency. Teaching is too entirely in the hands of the learned, who, as Hazlitt has told us, are necessarily ignorant. The University of London will only have parrots.

Some drastic means of reform must be found. Disraeli, who foresaw most things and long ago commented on our neglect of architecture, a subject only recently the topic of discussion, said, that what was wanted in Architecture, *as in most things*, was a man. To attempt to find refuge in a Committee of Taste would be to escape from the mediocrity of one to the mediocrity of many. "One suggestion might be made —no profession in England had done its duty until it had furnished its victim. Suppose an architect were hanged? Terror has its inspiration as well as competition." Suppose a selection made of present leaders not only from the schools but from employers and from trade unions and that the chosen were dealt with by some striking lethal process? The example might at least give rise to thought.

Thought of coal can only make one white hot with wrath in these days. Clearly coal is at the root of most of our difficulties: we are suffering severely from a *Coalitis* brought on by the unreasoned use of it as fuel and gross neglect of the things of the spirit.

Are we never to cease from using coal to base purpose and from making it the cause of our quarrels? Rather should we weave pure ideals and romance around its use and learn to rate it at its true value. Some halt we must call in the race to destruction; some organised effort there must be to make knowledge of avail: at present, it seems to be given no part in the conduct of our affairs; we are governed only by opportunism. As I shall show presently, we are but trying to do to-day with coal what was done successfully a century ago.

That science can kill is now fully recognised; few see that it has the power of curing souls; the fault rests mainly with its priesthood, who are so occupied in looking into the future that they fail to take the most elementary precautions to safeguard their advance.

Nothing is more wonderful than the significance of language, the power of the human mind to put meaning into its symbols; and yet words rarely evoke their proper response. We have little desire to plumb their full meaning. No word in constant use has suffered more from this neglect than has "*Coal.*" The schools heed it not, the so-called organs of public opinion are in no way concerned to give it vogue; nothing counts but price per ton.

If we were seeing, reasoning beings, we should worship coal as our most priceless possession—worship it as the greatest of Heaven-sent blessings, those of us who are orthodox; the rest, in any case, would worship it devoutly, instead of wasting it always. Worship, let me say, has been defined by Carlyle as "transcendent wonder; wonder for which there is now no limit or measure: that is worship." Such worship Coal deserves.

We may become excited over matters of no public consequence—why not over matters that count? Only recently Science had its Big Gooseberry Season, a virulent

new German disease, *Einsteinœmia*, suddenly making its appearance among mathematicians; a not inconsiderable section of scientific workers was laid low by it; one week it entirely overcame *Nature*.* The infection was also caught by that most resistant of our institutions, the Press, which as a rule is immune to Science, though often sensitive to Spooks, being in the hands of an opportunist class that knows not Joseph and has no outlook on the future. The dear old *Times* was the most severely affected; but this is not surprising, in view of the example it sets, in its special article, at the end of each week, encouraging readers to have faith and say their prayers—at the same time seeking to destroy our faith in the one object of worship that is left to us, our Prime Minister. Suppose *The Times* were to realise that there are serious subjects to be dealt with and each week devoted a column to Coal? People would begin to ask—"What is Coal?" No other material affords the same opportunity of teaching Duty to one's Neighbour. It is at least equal in importance to pigeons. Literary writers are allowed to prose *ad nauseam* on subjects of no consequence—why cannot we recognise that the world now has real needs and that literary tags have lost their value? We must seek to deal with what is.

The dealers in the "let it be granted" are a great race, whether they belong to the church or to some other condition of life. By adding a fourth dimension to their speculations, the Einsteinæmics have extended their conceptions of the Universe and have evolved a novel doctrine of *Relativity*. They would have us modify not a few of our long cherished beliefs; but it will be safer to suspend judgment. Some of us take the liberty of awaiting proof, before classing speculation as theory: unfortunately we are so Greek-less to-day, that the distinction between hypothesis and theory goes unrecognised. And we have it on no less august authority than that of "*Our* Scientific Correspondent" in *The Times*, that the new supra-mundane doctrine is not for ordinary mortals. It is comforting to be told that—

> "those who are not advanced mathematicians must reconcile themselves to inability to understand Einstein's formulae—Einstein uses a geometry of four dimensions and human experience does not contain the materials out of which the imagination can build a picture in more than three."

Our present state would seem to be one of no imagination in any dimension. In effect, the new cult is but a recognition of the fact that "we don't know where we are" in the Cosmos—which is certainly true. Whatever the ultimate fate of the philosophers' dream, it is clear that we have far too long neglected to develop and apply a sound doctrine of *Relativity* to our sublunary affairs.

We don't really know where we are to-day but at most are aware that we are where we are with reference to others and in no absolute sense. The opportunism which has so long characterised our actions must make way for some considered course: a dimension, if not a fourth, of organised intelligence, within human comprehension, must be imported into our affairs.

Time was, centuries ago, when the nations led an isolated existence and were happy according to their lights. Unfortunately certain restless individuals, who in the good old days would have been knocked on the head—very properly—as disturbers of the peace, instead of saying as their fathers had done, "I don't think," began to whisper "I know." A magic password came into their possession and they were able to forge an entirely new key—the experimental method: armed with these and infinite courage and perseverance, they were able to unlock the caves of knowledge, to penetrate far and wide into their utmost ramifications and to discover an astounding treasure. Why is not their story listened to everywhere? Surely, if *Chu Chin Chow* can be played nightly, during five years, to crowded houses, by characters clad in colours from coal, if we had any histrionic talent among us, we should stage a far more entrancing drama dealing with King Coal himself.

The new Wizards have relentlessly mouthed their "Open Sesame" during a century or so. Their key-word has been simply "Science"—but the modern Ali Baba, who has battened on their findings, loads his poor stupid ass with the electric telegraph, railroads, steamships and cannon. The forty thieves behind him began by taking toll of the Sun's ancient hoard of black diamond and flashed the jewel most arrogantly the wide world o'er. As do all who acquire a fortune beyond dreams of avarice, Ali Baba and his friends have

squandered in every direction. Unfortunately they have shared their plunder with the multitude and as a consequence morals have been abrogated universally. Worse still, all the peoples have been brought into competition and conflict. Our earth can now be so swiftly encompassed with a girdle that national independence is no more. The recent war was but the inevitable consequence of an overwhelming confidence bred of the scientific uses to which Nature's hoard may be put—of a confidence without touch of altruism, let alone understanding.

The writing on the wall was never more ominous. It is clear that our civilisation is not even skin deep; that it takes little to bring the elemental man to the surface; that he is ever ready to see red.

> "With all their enormous differences in natural endowment, men agree in one thing and that is their innate desire to enjoy the pleasures and to escape the pains of life; and, in short, to do nothing but that which it pleases them to do, without the least reference to the welfare of the society into which they are born. That is their inheritance (the reality at the bottom of the doctrine of original sin) from the long series of ancestors, human and semi-human and brutal, in whom the strength of this innate tendency to self-assertion was the condition of victory in the struggle for existence. That is the reason of the insatiable hunger for enjoyment of all mankind, which is one of the essential conditions of success in the war with the state of nature outside; and yet the sure agent of the destruction of society if allowed free play within."
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> Evolution and Ethics. Huxley's Collected Essays, Vol. IX.

The verdict of science must be against those who foreshadow an alteration of our nature: the records of the past are proof to us that it has little if any structural plasticity and it is obvious that education cannot modify us materially. If we were in any degree plastic, we should not be what we are; no type would be long preserved. The implastic races are those that are likely to survive.

Only by the application of breeding methods, consciously or unconsciously, can we produce a change. Such change is proceeding but in the wrong direction. Mephistophelian science garbed as humanity is everywhere encouraging the propagation of the unfit and promoting their survival: the lesson taught by Darwin is nowhere regarded. War, instead of strengthening the race, has deprived us of our best stock. The intellectual man is fast being taxed out of existence—he cannot afford to breed. The intellectual woman is now seeking for man's scalp in every direction and through education is lowering her domestic attractions, even her human desires. Raisers of stock know full well that the consequences must be: good milkers cannot be bred from a milkless herd. Chemists, perhaps, more than any other class of worker are entitled to pronounce an opinion on these matters, in view of their intimate knowledge of ultimate structure and of the structural peculiarities of living matter as influencing function: all modern work tends to show that we are largely the creatures of a chemical control.

Mr. Wells, who clearly should have been a Bishop—he has all the qualifications of a cleric, including those of a complete self-esteem bordering on infallibility—would have all the peoples united in one great World State: but having proved that he cannot feel the pulse of the past* he need not be taken seriously as wearer of the prophet's mantle. Nominally, Mr. Wells received a scientific training; actually, it may almost be said of him, as was said of Mr. Gladstone by Herbert Spencer, that he is the type of the unscientific mind—a dreamer. It is clear that the lessons of anthropology and of history are without meaning to him—otherwise he could not contemplate the peaceful browsing together everywhere of the lions and lambs of the earth. In the past the peoples were happy because they were apart; but the black diamond has demoralised all but savage societies—and the missionaries account for these.

Mr. Wells would have the Americans believe that the railways came as an unqualified blessing to the United States. Actually they have ministered to human selfishness and greed in the most deplorable manner possible—a vast continent has been depleted of its natural resources within three or four generations in an inconceivably ruthless and inconsiderate manner: the great oilfields, opened up only about 60 years ago, will be worked out, we are told, within less than a century. The country has been peopled, not by a natural process but by overflow—it has, in the main, served

* See Mr. Wells as Historian. An inquiry into the facts of Mr. H. G. Wells' Outline of History which dealt with Greece and Rome by A. W. Gomme, Lecturer on Greek in the University of Glasgow.

as the safety valve of the European continent and the Asiatic overflow is now seeking entry.

The sway of the black diamond over the American continent has therefore ministered to the undue multiplication of populations in Europe. In this country, we know, there has been an enormous increase of population since the so-called industrial revolution set in. Some halt must be called.

In the near future, if we have any regard for coming needs, the present efficiency of coal-using appliances must be quadrupled and only half the amount raised: then at most half the number of miners that is now employed will find occupation in the industry. America will not always swallow up the surplus of other nations—the moral is clear.

A true doctrine of Relativity should enable the nations to define and preserve their respective positions. The opportunism which has so long characterised our actions should give way to some considered course. So long as coal can be had at prices at which it can be used we must remain united in one inharmonious whole—and put up with each other's interference as best we may; but the wand of Science is now passing into the hands of the East. An we be not careful, world-wide quarrels may easily arise. Recent publications on the "Conflict of Colour" are of absorbing interest in this connection.

Apart from coal, sooner or later, if we encourage the growth of populations at modern rates, the struggle for food will be unavoidable. Few see what are the governing and limiting factors of supply. More than once I have pointed out from this platform, that we must take heed of the rapidly growing depletion of the stores of phosphate—this and potash, rather than coal, are perhaps the limiting factors of the world's advance.

Science hitherto has been used chiefly on the side of competitive industry and on that of sentiment, in entire disregard of the main principles of evolutionary doctrine. We have far to go before we make right application of our modern pass-word—to school ourselves against the ignorance and false sentiment which bar our way to the provident use of the materials won from the cave of knowledge.

The world needs a new religion—it may well find one in the recovery of the most ancient of all, that of Sun Worship, by making Coal the chief object of reverence. Unfortunately, though ever glad to bask in its beams, we have not even the savage's wonder at its might—our children are in no way taught to understand and glory in their dependence upon its lustre; or to realise that they are not merely warmed and cheered by it but fed with its aid; or to rejoice in their heritage of coal, as witness of the Sun's considerate activity on their behalf in the far distant past: to see that it is their Capital.

The more we penetrate into the mystery of the Universe, the more marvellous it becomes. Speculation has long been rife as to the origin of the Sun's heat. Now we are beginning to think of our luminary as constituted not of elementary materials as we know them but largely of the finer materials of which these are composed: in fact, we are beginning to think of matter as built up of atoms of electricity—electrons—and the Sun's output of energy as largely generated in the gradual building up of the elements from these finer constituents.

The Sun's rays, falling on the plant, enable it to grow at the expense of the carbonaceous food presented to it in the atmosphere—only to the extent of 3 parts in 10,000. Eating plant food, we are able to utilise the carbonaceous building-stones fashioned in the plant, with the aid of solar energy, from air, earth and water; hence we are heirs of our Sun. Much of the carbon assimilated by plants in the far distant past has been preserved to us as coal. So that in coal we may read an epic with which none that is written in books can compare. The Scribes, let alone the Pharisees, have nothing to offer which can be set against this knowledge—and yet we make no use of it in our system of education.

At the meeting of the British Association for the Advancement of Science in Belfast, in 1902, we were entertained by one of the Clubs at a Smoking Concert. A programme was provided with illustrations topical of tit-bits from the Sectional Addresses. Among them was one of a literary man sitting on the floor gazing blankly at a coal-scuttle, with the script, "A scuttle full of coal excites no emotion in the literary mind" (Professor Armstrong). The artist of to-day might well take our Minister of Education as his model of the literary man. In no speech of his have I ever noticed a reference either to coal or to the Sun—yet he has had much to say of the value of

reading. A Minister who has thought some meaning into the things of life and will advocate attention being paid to them in the schools has yet to be found. Let us hope that one of the numerous Coal Controllers of the past, if not Mr. Smillie, will be offered the office at the next vacancy.

Whatever be behind the veil, so much of her secret has now been torn from Nature that science can give no credence to the crude and selfish anthropomorphic interpretations of the past. Unfortunately, mankind is weighted with mental disabilities acquired in a superstitious period of long duration, now perhaps inseparable from his structure; but at least he can be taught that, in the long run, the safety of his skin will only be secured if he make proper use of the opportunities at his disposal.

The future of civilisation depends on our right use of coal and all must learn to treat it with respect. It must be an object of transcendent wonder to those who can in any way picture its story and realise its potentialities, who can grasp the fact that its main component is the basal unit of our own structure and that the mosaics of that structure, to the all-seeing eye of the chemist, are of patterns of a most exquisite, ordered beauty but at the same time of extraordinary fixity of design, administrate of an iron purpose.

The problems of coal cannot be dealt with simply or by any one interest in an effective manner. In no other field of action is co-operation so essential to success—the tasks are beyond the power of individuals; there must be a combination of forces—many heads now unwilling to approach must be knocked together. We have to consult convenience as well as aim at economy.

Smoke Prevention.

Not a halfpenny should be spent, not a minute wasted, in further inquiry into the "Smoke Nuisance". Such inquiry can only be futile. Legislation will be impossible until we have approved means of preventing smoke.

Much has been said of late as to the need of introducing Art into common life. As Mr. Newton has pointed out, in a recent letter in *The Times* (March 30), the movement can have but little result unless we get rid of smoke. He paints the effect of smoke in lurid terms but there is nothing new in his recital. The degrading story has been told over and over again—yet no one does anything. The only possible solution is to use smokeless fuels.

Smokeless fuels are of two kinds, gaseous and solid. Each has its special advantages, each its disadvantages. I believe we need to use both in our domestic life; they are natural partners and can be made mutually helpful. History will but be repeated should their correlative and balanced use be secured in the early future; they were in use together a century ago but the one has long since been improved into oblivion and the other is now a hopeless weakling.

The foundation of the Gas Lighting Industry is to be dated back to an experiment made by one William Murdock, in his backyard, in 1792. Heating coal in an iron pot, he caused the gas which was given off to pass through a pipe into his house and burnt it as a domestic sacrifice at the altar of coal—but the public, having no regard for symbols, never puts significance into the flame.

Murdock's invention, as is well known, was gradually developed, first at Boulton and Watts' Soho Works, at Birmingham. In 1810 an Act of Parliament was passed authorising the formation of a Statutory Company to supply London with the new gas. Two years later, the Company became known as the Gas Light and Coke Company; though existent to-day, the Company has never more than half justified its name and the splendour of its flame has steadily diminished with the years.

Most interesting particulars of the industry were published in 1819 by Frederick Accum, well known as the author of several chemical works and, I believe, at one time, an assistant to Sir Humphry Davy.

The coal was carbonised in cast iron retorts, preferably of cylindrical shape—about 2 bushels of coal, in a layer 5 to 8 inches thick, per retort. Apparently they were worked at about a cherry-red heat, probably not exceeding 700°-750° C. The carbonising period was from 6 to 8 hours; but Accum gives details of several series of trials, carried out at the Westminster station, to ascertain the best time of heating, from which the conclusion was drawn that 8 rather than 6 hours was the preferable period. The average yield of gas in these trials varied from 8300 to 10,000 feet per chaldron (27 cwt.) of coal—say 6150 to 7400 cubic feet per ton. From the balance

sheets quoted by Accum, it appears that the coal cost £2 11s. 6d. per chaldron; the coke sold at £1 7s. 0d. per chaldron and the gas at 15 shillings per thousand cubic feet. It is clear that the gas will have been rich and the coke not very hard.

Accum writes with extraordinary enthusiasm of the use of gas both as an illuminating and as a heating agent. Mr. Maiben had ascertained, he says—

> "that gas from coal gives nearly the same heat when put into combustion which is yielded by a third part of the coal from which it is extracted.
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> "There are no coals to be carried in, no ashes to be carried out; there is no blowing, no sweeping of cinders, no dust, no interruption of servants; there is no excessive heat in one stage, no sudden damping at another; we have the choice of any temperature which we can regulate with the utmost ease. The fire itself is lively and pleasant to the eye; inclosed in transparencies it receives a degree of splendour not easily imagined."

Evidently gas was gas in those days; and as to the Coke—

> "The coal is so far from being reduced in consequence of the gas-light process, to an useless mass, that in many places immense quantities are reduced to the state of coke for the purpose of rendering the coal a better fuel than it was in its natural state; for coke gives a strong and lasting heat. It is equally valuable for kitchen and parlour fires and still more as a necessary requisite in some important branches of manufacture, so that in whatever quantity coke may be produced, it can never want a good market. The demand for coke in this capital, since the establishment of the gas-light works, has prodigiously increased. Numerous taverns, offices and public establishments which heretofore burnt coal, now use coke to the total exclusion of coal; and in almost every manufactory, which requires both extensive lighting and heating, gas and coke are now the means jointly employed. A coke fire emits a very uniform and intense heat; it produces no sparks and burns free from soot and smoke."

Why, a century ago, when soft coke became available, did people turn from coal to this new material? Surely because it was a clean, honest fuel, not a dirty one. They would do so again to-day for the same reason, if the chance were given—nay, more, no one would object to the use of such fuel being made compulsory, the smoke nuisance is now so terrible in its effects.

Why is coke gone out of general use as a fuel? Because neither Science nor Relativity has troubled the gas engineer; he has simply concentrated his attention on producing and piping gas. When the demand for gas grew and it was necessary to cheapen the supply, the temperature of carbonisation was raised, so as to produce a larger volume of gas. So long as iron retorts were used, little could be done; but as soon as fire clay retorts were successfully introduced, it became possible to raise the heats very considerably. More gas was obtained, it is true; but the coke became useless for domestic purposes, too much burnt-out to kindle easily and give a cheerful fire in an ordinary grate. The rot set in 60 to 50 years ago—from that time on the quality of gas was steadily reduced: a curious losing race between gas and burner took place; whilst burners were greatly improved, gas was reduced in illuminating efficiency and heating power, as the Companies were allowed to use the better burners in testing it.

Protests were made on behalf of the public by my old chief, the late Sir Edward Frankland—but without effect. At the time of the panic consequent on the introduction of electric light, the gas industry came near to death's door and was only saved by the introduction about five and twenty years ago of the Auer von Welsbach mantle—which not only made intrinsic illuminating power of secondary consequence but permitted a gas of low heating power to be used with effect. Now the gas companies are cheerfully carting considerable quantities of atmospheric nitrogen about in their mains—not merely running ill-filled trains but putting stones in place of the passengers who should be forthcoming. Ours is an age of progress; something must be forced to move.

My interest in coal and gas dates far back. A student under Hofmann, Frankland and Kolbe, I naturally gave special attention to organic chemistry. Kolbe introduced me to Phenol in 1868: I have always maintained the greatest affection for this my first coal-tar love; there is no more engaging minx among one's chemical sweethearts. No lecture course ever made so great an im-

pression on me as did that of Frankland delivered in 1867, at the Royal Institution, in which he demonstrated his views on the origin of light in flames. I increased my acquaintance with the Phenol family during the seventies and found them a charming group. Then I was led to turn my attention to the manufacture of gas from oil and especially to the By-products, thus entering upon a neglected line of inquiry opened up by Faraday in 1825. Accum has a chapter on "Gas from Oil," which is copied from the Journal of this Society (VI, p. 108). It is noteworthy that, in those early days, gas from oil was supplied compressed into portable vessels which were the fore-runners of those in which hydrogen, oxygen, acetylene, etc., are now purveyed; and that, four years hence, we must celebrate the laying of the foundation stone of the Coal-tar Colour Industry a century ago, in the Royal Institution, Albemarle Street, by Faraday, through the discovery of benzene in the liquid produced on compressing oil-gas. To judge, however, from the recent events, especially from the military occupation of the Directorate of our Government enterprise, it is not improbable that, by that time, there may be no Coal Tar Colour Industry left in the country and that we shall but be doing honour to the pious founder—of German industry.

In 1885, I ventured to address the Iron and Steel Institute on the recovery of the matters latent in coal, as completely as possible and in the most economical and advantageous manner and form. In concluding my brief harangue, I pointed out—

> "that we know practically nothing of what happens when coal is distilled or of the conditions most favourable to the production of the valuable constituents of tar. Until we possess adequate knowledge on these points, the coking of coal and the manufacture of gas from coal and oil are empirical operations and cannot be scientifically conducted. It would not be difficult to gain the required information but the aid of the chemist must be sought and the experiments must be on a moderately large and therefore expensive scale. Our private dabbling with tars from various sources can never lead to a really satisfactory result. The interests involved are so great, the subject is one of such national importance, that failure to initiate and execute the necessary systematic experiments without further loss of time is simply inexcusable." *

Of course nothing came of this appeal to the myopic vision of coal owners and coal users.

The late Prof. Vivian B. Lewes, in his Cantor Lectures on Fuel and its Future, delivered before this Society in March, 1908, calling attention to a paper read before the Society of Chemical Industry, twenty-two years previously, by Mr. Lewis Wright, under the title, "What shall we do with our tar?" remarks, that—

> "In the discussion that followed the paper Dr. Armstrong asked the pertinent questions—Was the gas maker right in his present method of treating coal? Would it not be better to deal with it so as to produce a large proportion of residuals and a different class of coke? In the twenty-two years that have elapsed since these questions were asked, the gas managers of the country have not only ignored them but have, with self-complacent egotism that brooked no interference, worked in the exactly opposite direction."

Being a patient soul, realising that nothing short of a deluge could wash out an intelligent interest from the mountains of prejudice, I continued to dabble with tars but said nothing more—until 1908, when I could contain myself no longer and again turned to the Iron and Steel Institute. I need only quote the opening lines of my communication—

> "There must be not a few at the present time who find it difficult to remain calm, when they reflect on the ruthless way in which the world's accumulated stores of raw material, especially of fuel, both coal and oil, are being used up; who shudder when they notice the indifference displayed in all civilised lands to the consequences which must accrue from such waste in by no means distant times to come."

The consequences are with us to-day.

In 1910 and again in 1913, I initiated discussion on the provident use of Coal at the meetings of the British Association for the Advancement of Science at Sheffield and Birmingham. These towns were not to be stirred. My advocacy of smokeless fuel in 1910 was quietly scoffed at by the

* Note with reference to the methods proposed for coking coal and recovering volatile matters. Journal of the Iron and Steel Institute. 1885.

Technical Press. Then came the war. I sought to awaken a coal conscience at a Conference in Cardiff early in 1915, later in the same year at Manchester, at Newcastle in 1916 and at Nottingham in 1917. There was great hullabaloo on this last occasion—but only because, copying Disraeli, I suggested that a little lynching might do good. The purists of the Society of Chemical Industry were so lacking in sense of humour that they would not allow the publication of my joking remarks. Short of going to the stake or hanging myself—more appropriately, perhaps, taking coal-gas—I could do no more. Others have had no greater success.

My final appeal must be to Cæsar here. To repeat words I used at a recent Conference at the Efficiency Exhibition at Olympia :

> It is to the lasting disgrace of the coal owners that they have not moved a finger to improve coal for public use, so that full value might be got out of it. It is to the lasting disgrace of the great users of coal that they have done nothing, either collectively or individually, to inquire into methods of avoiding the great waste involved in the use of raw coal.

Sheffield, to take an instance, for years past, has been a disgrace to our civilization : nowhere else has there been such culpable waste of coal.

Production of Smokeless Fuel.

It has been left to the business promoter and visionary to save the situation. Though absolutely unscientific and liable to be misled by their agents, workers of this class are human and their ways therefore appeal to human nature, whilst the cold calculations of science pass unnoticed ; and being free from professional limitations, seeing the promise and not the difficulties, they are enterprising and hopeful. We constantly blame their methods and they sometimes mislead us badly ; but these Mark Tapleys of the world have often intervened with success and unless Relativity be made to count in our affairs, it will be long before we shall do without their assistance.

The history of the solid fuel enterprise I propose to deal with, as far as I can gather it from scattered items of information, is briefly as follows. It is a chequered story, one showing up the petty behaviour of vested interests and the extraordinary narrowness of vision of our industrial leaders.

Two men chiefly have been concerned in the invention—I use the term "invention" advisedly, as the fuel I am about to speak of is a novel and distinct product of a kind unknown prior to 1905—Mr. F. W. Salisbury-Jones, who throughout has been the moving spirit ; and the late Mr. Thomas Parker. The former began his career under Rhodes, in South Africa, hence his invincible optimism and dash.

Mr. Parker, who was born in 1843, commenced life in the Coalbrookdale Iron Works and began by lighting the fires for the men at half-past five in the morning—so his attention was early directed to fuel. In 1881, he designed the house grate known as the Kyrle, winning the first medal offered by the newly formed Coal Smoke Abatement Society. Leaving the Iron Works, he entered the Engineering trade. In 1878 he designed and built a Dynamo for use in the electro-deposition of metals. He then entered into partnership with Mr. Elwell ; the firm was well known in the early days when Ayrton, Perry and I were witnesses of the birth and rapid growth of the Electrical Industry consequent on the introduction of the electric light and then of electric traction.

Mr. Parker was a man of great originality and full of scientific enthusiasm.

In 1900, he was engaged on plans for the electrification of the Metropolitan Railway in London, which was afterwards carried out under his direction ; Mr. Salisbury-Jones with his brother was busy in developing the Motor Bus. The two pioneers often came together ; meeting at the fireside, at a time when the smoke nuisance was the subject of constant complaint, they began to discuss the possibility of producing a solid fuel, which would burn easily and cheerfully as a clear fire does without producing smoke, by subjecting coal to a treatment similar to that to which it undergoes in an ordinary fire—*i.e.*, carbonising at a relatively low temperature.

The electrification of the Metropolitan Railway was complete in 1905 and the Motor Bus industry was well on its feet at about the same time. Mr. Parker and Mr. Salisbury-Jones then entered upon the spceial study of the problem they had formulated in their minds : the experiments were carried out at Wednesfield near Birmingham, where Parker had made preliminary trials in 1903.

It is of importance to note that, in the

first experiments, a tube three inches wide, perforated with holes, was filled with coal and fired inside a larger "retort," to the point at which illuminating gas ceased to be given off. The result was most satisfactory—the fuel was compact, so that it would withstand handling and carriage; it was not only easily kindled but burnt readily in an ordinary grate, giving the cheerful fire required. The coal had been carbonised under pressure, as it were, whilst the volatile matter could escape freely. The need of carbonising in such a way seems to have been generally overlooked—hence the impression abroad subsequently, when the new fuel began to be discussed, that low temperature Gas Works coke was a similar product.

In the earliest large scale trials, tapered, wrought iron cylinders were used, closed with perforated caps; these, I am led to believe, were about 5 feet long. Such cylinders, 10 to 12 inches in diameter, are referred to in Mr. Parkers' patent specification (No. 14365, 1906), where the importance of filling them with coal is emphasised. The cylinders were heated in a flat bottomed reverberatory furnace; they were introduced at the one end, gradually rolled to the other and then taken out, fresh ones being introduced as they were removed.

He soon passed to vertical carbonising vessels, heated all round. One of the earliest ovens was made 12 feet high, 4 feet across and 12 inches wide at the bottom, tapering to 8 inches at the top; this was built up in sections bolted together. A set of four of these was worked but the charge was too thick and became overheated on the outside and insufficiently within; also the coked mass stuck badly.

At an early date Mr. Parker cast the retorts of an inverted V shape; at first, they were made about 3 feet high, 6 feet broad and tapered from 3 inches at the top to 4½ inches at the bottom; but ultimately the dimensions were increased up to 12 to 14 feet high, 11 feet long and the tapering from about 3½ to 7½ inches. A satisfactory thickness—about 3/8ths of an inch—was arrived at only after many trials. Some were cast with plain, some with corrugated sides.

He also tried long, tapering vertical tubes and obtaining good results proceeded to cast a dozen of these together in two rows of six, each 6 inches in diameter at the top and about 12 feet long. He was indifferent as to thickness, thinking that heat would travel easily through iron. A plant was built of 24 of these units ranged side by side and occupied an area only 20 x 40 feet; this gave an output of 40 tons of the fuel per diem. I myself saw this plant in operation.

Initially castings were obtained from outside but these proved to be so unsatisfactory that Mr. Parker became his own founder, utilising his early experience in an iron works; much of his success appears to have been due to this circumstance but, on the other hand, the mania he developed for casting seems to have led him to neglect other essential factors. Thus he never gave adequate attention either to the oven-bottom or to letting down and cooling the heated charge. He was undoubtedly hampered by his lack of gas engineering experience; like so many inventors before him, he was overcome by an all-convincing belief in his idea and in his ability to solve it alone; he certainly obtained very remarkable results.

The new smokeless fuel was registered as Coalite in 1906 and was very widely advertised. A syndicate was also formed to provide the further funds required for the prosecution of the inquiry, necessarily a very expensive one. The foundry was extended and the plant increased. The results were so satisfactory that it was decided to form a larger Company — to purchase the patent rights, the Wednesfield ground and plant and a property at Barking for new works.

Let me here quote a dead witness, the late Prof. Vivian B. Lewis (Cantor Lectures on Fuel, 1908), as to the position at this time.

> "The idea being taken up and vigorously pushed in the City resulted in the formation of a Company and the shock which the *amour propre* of the gas industry received at finding amateurs gravely proposing to show them how coal should be carbonised roused in them a feeling of rabid resentment which was admirably reflected in the articles of the leading gas journals."

Any one who takes the trouble to read the Press notices of Coalite in 1907 will realise that this is a mild description of the virulence displayed in interested quarters. Far worse was the direct action taken by the Gas Light and Coke Co. in issuing the following advertisement (in June, 1907):—

CARBO
The Gas Light and Coke Company's
NEW SMOKELESS FUEL.
Made in ordinary Gas Retorts.

Clean to handle.
Lights readily in the ordinary grate without the assistance of coal.
Quickly attains a state of Incandescence.
Gives out great Heat.
Is absolutely Smokeless.

This advertisement was fatal to the proposed company and most seriously crippled the enterprise. "If the *new fuel* could be made at any moment by the Gas Co's., why form a new Company ?" was the argument. As a matter of fact *Carbo* was found out by the Public within a year and the Gas Companies never became purveyors of a fuel comparable with Coalite. Gas Companies Coke was long a drug in the market and was selling at 9/- per ton just before the war in 1914; but the effect remained—Coalite was discredited.

However, the Company was formed and a plant was erected at Barking, the works at Wednesfield was extended and plants were erected at Plymouth and Hythe. At least 100,000 tons of Coalite were made at the different works. Much of it was magnificent in quality. One of my oldest friends, a chemist and a judge of fuel, I well recollect was enthusiastic over it at first but afterwards dissatisfied. Reminding him of this, he has just given me a sample which he put aside in 1906 or 1907. I have not yet myself seen anything so good produced.

Every variety of coal seems to have been tested and here a mistake was made. The early advertisements promised a fuel low in ash and that first produced was of this character; unfortunately, in the desire to show that all coals could be made into fuel, much unwashed coal full of ash was used: naturally users were not pleased with the product. Then some of the Coalite put on sale was very like ordinary coke, through being overheated.

Unfortunately, after about two years, the battery of iron retorts at Wednesfield became distorted—too slim in the waist—and the carbonised fuel could not be discharged without forcing: I imagine that the iron began to "grow" through oxidation. This led to the production of a very high percentage of Breeze or Smalls. The best way of getting over this difficulty appeared to be to substitute firebrick for iron but the funds to make the change were wanting; none the less experiments were begun in this direction.

Although the enterprise, on the whole, failed to meet with support here, the Germans were more alive to its value. Early in 1913, a big German Coking Interest made the proposal that, provided they were satisfied with it after a year's trial, they would join with the Coalite Company in developing the process. An agreement was entered into and a most striking contribution to the process was soon made by the Germans, as they sent over a retort, similar to the smaller V-shaped retorts that had been made in iron by Mr. Parker, *cast whole in fire clay.* Here, in the backward state of our refractories industry, the feat was impossible and probably is still. The Germans were satisfied with the trials they witnessed and eventually sent over a staff to start work on the erection of a complete plant: shortly after their arrival came the war.

Mr. Parker retired in 1914, entirely disheartened, feeling that the opposition of the gas interest had made success impossible. He died in 1915, as did also Prof. Vivian B. Lewes, who had been intimately associated with him in the Wednesfield inquiry from the beginning. With these two men perished most of the fruits of knowledge gained at great expense over a long period of years. Such has too often been our experience in the past. The mistake made was in allowing Mr. Parker to work apart: whilst too many cooks spoil a broth, the preparation of a banquet needs a number; but the inventor is a jealous creature and naturally attaches an exaggerated value to his idea and is not sufficiently alive to his limitations.

Experiments at Barnsley.

To pass now to my own experience of the process. I knew of it only from hearsay up to 1908. Some time in that year, the then Chairman of the Company, the late Sir Wm. Preece, F.R.S., who was long the chief Electrician of the Post Office, whom I met not unfrequently at our Club, the Athenæum, invited me to join him in a visit to the works at Wednesfield. I did so and paid a second visit, perhaps a year later. At that time I gave no special heed to the fuel side of the problem: but the

plant referred to on page 394, described in *The Times* of October 27th, 1908, was in operation and I saw several charges dropped; I remember that it was necessary to force some of them down. I was more concerned with the tar, which I knew must be unlike ordinary Gas Works Tar, so spent my time mainly in trying to ascertain what had been learnt about this product of the process and arranging that suitable samples of the crude material might be put at my disposal for study. The "Chemist" in charge was one whose soul had not risen much above the extraction of carbolic acid from the tar and my efforts to extract information were generally foiled in the way that has not infrequently been experienced by the "Professor" in the past, when he has visited a works—only to be viewed with suspicion. I formed the impression that this part of the work was of the usual empirical order. Much work was done with the tar in my laboratory and in opening the discussion on "The Provident Use of Coal" in Sheffield in 1910, I gave an account, in general terms, of my results.

Sir William Preece falling ill, I heard little more of the enterprise until after the publication of my Newcastle paper on "The Problems of Coal with reference to the complete and provident utilisation of the supplies and of fuels generally: a preliminary discussion and scheme," read February 19th, 1916, in the Journal of the Society of Chemical Industry, in which I had referred to Coalite. I received an invitation to visit the office of the Coalite Co. to inspect the plans of works then in course of erection.

I was shown a most impressive set of working drawings of a plant to be erected near Barnsley (Yorks): I could get little explanation of their origin but it seemed to me, at the time, that they savoured largely of German inspiration in their minute elaboration. However, being no judge of paper plans, I asked to see the works and was granted the privilege of visiting them at frequent intervals. I had, at this time, realised the enormous potential value of the process as a source of oil fuel and was anxious to render what help I could. When I first went down, little more than the foundations were laid: progress was exasperatingly slow under the conditions which then prevailed, as skilled labour was scarcely to be had; and delivery of material was very slow. The most distressing of the many object lessons the works afforded was the inferior quality of the refractory materials: few if any of the bricks supplied for the construction of the ovens were of specified size and it was necessary to grind and shape them before use: one felt that much of the strength was being taken out of them; and the cost was great.

I was present during the first few days when carbonisation was begun and on numerous later occasions. It was soon obvious that no one of the staff had had any previous experience of the process and that the experience gained by Mr. Parker had been cast to the winds; it was also clear that an exceptionally intelligent set of men was required to work so complex a plant: it soon appeared that most serious errors of construction had been made.

The large inverted V-shaped ovens were gas fired, by means of numerous burners fixed one above the other. No scrubber was provided to remove dust and tar from the gas as it issued from the Mond Producer. Consequently, the burners were constantly clogged by tar and the regulation of the heats was very difficult.

A refined and most costly machine had been constructed for the discharge of the ovens. This was a carriage running on rails, provided with two rams which could be electrically driven by a dynamo on the carriage. These rams were to be moved up and down through two tall boxes, so as to bring down the charges from the ovens above into these boxes, where the hot coke was to be cooled off by the external application of a water spray projected at the sides of the box by a small pump on the carriage. The expectation was that the charge would just drop out of the oven when the door was lowered; and that it could be cooled off in very few minutes. The carriage was to be moved to a discharger, a short distance off, where two hydraulic rams were to force up the bottoms on which the charges had been carried down into the boxes and in this way push out the cooled material on to a travelling band. Everything was to go as greased lightning. It was all perfect on paper—but as often before, beautiful theory was killed by ugly fact.

When the ram was run up until it was under the door closing the bottom of the oven and the catches were released, the door came away as the ram was lowered—but this bottom rarely carried the charge. During coking, the coal had expanded but had not

afterwards contracted sufficiently to be free at the sides; pressure from above seldom sufficed to move it and it was necessary to hack the burning mass out from below. The difficulty was never overcome and the discharging machine was soon put aside and the charge brought down on to a jury platform, where it was cooled off by squirting water on the glowing mass—a senseless proceeding, which ruined it as a fuel. Coalite must not be touched by water.

On the few occasions when the charge came down into the cooling box, this proved to be entirely ineffective. I believe the cause to have been failure to close the openings properly at the bottom and top of the box, so that the charge burnt merrily inside, through in draught of air, counteracting the vain attempt to cool it from outside.

A third serious fault was at the oven bottom. This was a long, narrow, cast iron box filled in with firebrick, in which a shallow channel was cut. A short curtain of thin iron plate was fixed to the oven bottom and when the door was brought into position, the curtain fitted into this channel; water being run into the channel, a water seal was provided. The door carried the charge of coal to be carbonised—naturally, as carbonisation went on, it became hot and the water boiled away. The water seal was altogether insufficient and at first provision was not even made to keep it filled. The leakage of air into the oven was therefore considerable, the charge was "overburnt," very little tar was produced and the gas was beneath contempt in quality. A better bottom was provided, after a time, with a deep water seal; but then the jointing between the retort and the iron curtain proved defective.

The experience was just that nearly all of us have had who have engaged in experimental inquiry: a first experiment rarely does succeed in the expected manner and more often than not more is learnt from an unsuccessful than from a successful first trial: the difficulties and weak spots are made apparent. So it was at Barnsley. The great mistake made there—and it is the mistake the engineer is prone to make—was to erect complete works before the efficiency of the primary unit had been established, even before the conditions of the problem, the requirements to be met, were fully understood: what is worse, without submitting the scheme to competent criticism of its details.

The first set of 9 ovens was soon rendered useless. Meanwhile a second similar set had been more carefully built: although this had the same faults as the first, now and then it was operated with some degree of success. Much more might have been learnt from it had the works managers been willing to listen to advice: as it was, the trials were unsystematic and unscientific and opportunities were wasted. I have never before had such an object lessson: never before have I felt so sure that we must modify our methods if we are to succeed in the future. To state my meaning in the one word in the English language which sums up the situation: if we are to solve problems of any importance, we must put them into the hands of gentlemen; of men who will recognise that even the youngest among us is fallible; who will subordinate the natural human tendency to be jealous of any and all "interference" in the interests of the cause to which they are committed: in short, who will realise the value of Relativity and seek to work in harmonious co-operation with others.

At the beginning of January, 1919, I wrote out a statement of the impressions I had formed, during 1917 and '18, from which I copy the following paragraphs.

"Judging from its appearance, the Coalite produced has been over-carbonised on the average; and the proportion of volatile matter has been unduly low. But these faults may be in part accounted for by the leakage of air into the ovens and especially the unsatisfactory method of discharging adopted, which has involved the exposure of the hot coalite to air and subsequent cooling by water.

"Although the amount of tar produced, in the later trials, has varied considerably, the average is not unsatisfactory, considering the difficulties encountered. The maximum produced on some occasions has been not far short of that expected. The most satisfactory point established, however, is the fact that the tar as a whole (less a small proportion of the most volatile part) has passed muster as an Admiralty fuel.

"It may therefore, be claimed that it is established that both a satisfactory solid fuel and a satisfactory oil fuel have been produced. Every improvement (especially the abolition of all air leakage) will undoubtedly be followed by an improvement in these two fuels; the rest

will follow when these are satisfactory.

"All that remains to be done is to construct an oven which can be operated satisfactorily and economically over a considerable period. Considerable difficulty may yet be experienced in effecting this object but it can only be a question of perseverance. The stake to be played for is one of such extreme public importance that any expenditure within reason will be justified and is called for.

"The results obtained with the second set of nine ovens are generally of so encouraging a character, that it appears to be desirable forthwith to construct a similar set, introducing the improvements in construction of the brickwork which experience shows to be necessary and making every effort to avoid leakage of air into the ovens during the carbonising operation. Modifications should be made both in the cover plates and in the oven bottoms to prevent such an air leakage. The attempt should be made to design a different form of oven bottom; one in which the charge is held up by a plate hinged to the bottom of the oven whilst the seal is effected by means of a separate light tray seems possible. The hinged plate might serve, when let down, to direct the charge into the cooling box; the curtain might be fixed at some distance away from this plate, on either side, so that it would not be disturbed during the discharging operation.

"The introduction of a simpler, better mode of discharge is imperative. Probably the Coalite could be delivered directly into boxes each holding the charge from one or two ovens at most, which could be covered up with tightly fitting lids and cooled off in water. Another possible method would be to provide a travelling stage under the ovens on to which the charges could be let down and then conveyed away rapidly into a cooling chamber; this should be closed in, as far as possible, so as to prevent the access of air to the heated Coalite.

"New simpler forms of oven should be designed and put into operation without delay. A far simpler heating arrangement than that now in use is indicated as desirable. Instead of a large number of burners requiring separate supply and regulation, gas might be introduced together with heated air from as few vents as possible into a mixing chamber, from which the burning gas might pass up vertical flues on the oven sides and down a central flue to the recuperator.

"Trials should also be made with lesser thicknesses of coal to ascertain if these could be carbonised so much more rapidly as to compensate for the lessened amount dealt with in each operation.

"As it is probable that the amount of smokeless fuel required in future will be relatively small, it will be possible to use selected coals for its production. The coal used in the later trials has been of one kind and apparently one that is not specially suitable—at least it has not been found that it contracts regularly to such an extent as to leave the charge free at the end of the carbonising period. It will be necessary to try a variety of coals, so as to discover the kind which will contract to the right extent to give free delivery on discharge.

"In addition to experiments bearing on the production of Coalite, however, the attempt should be made, without delay, to devise plant for the continuous carbonisation of coals which could not well be converted into Coalite, so as to separate their volatile constituents (gas, ammonia and oils) as completely as possible; the residue should be charged immediately into producers and gasified.

"To carry out a programme such as indicated above will not be an easy matter: it will be a costly enterprise and will only be feasible and successful if a competent staff be secured and all concerned can agree to work harmoniously together and to co-operate at every stage of the operation. The old English system in which each foreman or director keeps everything to himself, in which no effective co-operation of different interests is secured, must not be allowed to prevail."

In May, 1919, the process came under a new management and the Company was fortunate in securing the services of Mr. T. M. Davidson, an engineer of original mind with a wide general experience. Three more ovens were built on the lines I have described. Studying these and dealing with the information that was available from the 1917-18 trials and the suggestions that had been made, Mr. Davidson soon grasped the essential features

of the problem and has met the difficulties in a peculiarly happy way. The plant built to his designs has been in operation since November, 1920, and is undoubtedly a practical success.

He has surmounted the expansion trouble in a strikingly simple and original manner, by building the oven, which is 11 inches wide, with upright walls and hanging in it two cast-iron plates in which numerous holes are drilled; these plates can be moved in a vertical plane over a certain narrow range. Coal is filled into the space between the side of the oven and the opposed face of each plate, so that the width of the charge can be varied; a space is left between the two plates. During carbonisation, the plates exercise the necessary pressure upon the coal; at the same time, the volatile matters can escape at numerous points into the central space between them, thus avoiding undue local pressure on the walls of the oven. When carbonisation is at an end, the charge can be released by moving the plates away from the coked masses. During carbonisation, the charge is held up by an iron plate closing the bottom of the oven; the plate is pivoted on a bar extending across the oven-bottom, so that it can be drawn aside by a lever at the oven-end.

The oven is built immediately over and in direct connection with an airtight chamber cooled by water on either side. A door at the front of this chamber can be opened, so as to allow of the discharge of the cooled Coalite.

In practice, the cooling chamber is first opened and the charge let down from a previous operation is raked out; the Coalite is so cool that it can be handled. The door is then closed and screwed up tightly.

Next, the oven top having been moved away, the bottom plate holding up the charge is drawn aside and the two vertical plates are then approximated and moved away from the two slabs of Coalite, which are then brought down into the cooling chamber below. The difficulties attending this operation are all but overcome: such as they are, they are obvious and will be met by slight adjustments. Of course, improvements are bound to come with use. The bottom plate having been brought into position, the vertical plates are adjusted, a charge is filled in and the top replaced. Carbonisation takes place in 5 to 8 hours, according to the thickness of the slab of Coalite produced.

I show specimens of the Coalite which is now being made, such as I have seen discharged on several recent occasions and have even picked up with my own naked hands as it came out. It is a perfect product, equal I am told to the best produced by Mr. Parker. I think, in recognition of the great service which he rendered, some day soon, as large a slab as possible, enclosed in a museum case, should be placed in some prominent position, as the most appropriate tribute that can be paid to his memory: perhaps under it will be placed an apology signed by gas-engineers throughout the country; being of a forgiving nature, recognising that we are all at some time miserable sinners, I will not advocate that Disraeli's suggestion be acted upon.

If the completion of the invention and the development of the industry which cannot but arise be not now supported by all concerned, if the use of smokeless, solid, fuel—now that it is possible to produce a suitable one—be not soon made general: then indeed we shall all deserve to be hanged.

Coal-Oil as Fuel.

Let me now refer to the liquid oily product obtained on carbonising coal at low temperatures. It is too soon to speak of its uses in definite terms—we have everything to learn concerning its properties. It is so different from Gas Works Tar and the Tars produced in making metallurgical coke that, in my opinion, it should not even be spoken of as Tar: then no confusion will arise; we shall do well to prevent confusion from the beginning. It will not be easy to find a name that will appeal. Coal-Oil as opposed to Coal-Tar may suffice for the present.

It is safe, in the first instance, to value Coal-Oil simply as liquid fuel; apart from cresol (cresylic acid), which is easily extracted from the oil by alkali, it contains none of the constituents of Coal Tar which gives this its special value. A certain amount of motor spirit may be separated from the oil and more of this can be scrubbed from the gas given off during carbonisation. In a practical test made by the Admiralty in 1918, the oil was found to be well within the specification in use for oil fuels.

Already in the fourth article in *The Times*, on Coalite, in 1908, the special value of a supply of oil from Coal to the Navy was not overlooked.

"Should it ever come to pass that oil becomes the staple fuel of the Navy—and already most of the torpedo boats and destroyers are fitted for the combustion of liquid fuel—an abundant native supply of such an oil would become of paramount importance. It is an intolerable position and one which offends the national sense of propriety, that this country should be dependent upon the foreigner for any part of the 'sinews of war.' The use of oil fuel has passed the stage of experiment. It is now among the accepted order of things. It is therefore of the greatest importance that a never failing supply of burning oils should be produced within these Islands." *Nov. 12th,* 1908.

Much has been said during and since the War of the value of what are now called Key Industries. In the event of another war, oil will infallibly be our key of keys. The geological probability that we should find oil, in this country, was never great and after the trials that have been made, little hope is left to us. Bearing this in mind, it is imperative that we protect the coming industry against any interference from the oil interests: they must not be allowed to follow the dog-in-the-manger policy displayed a few years ago by the gas interests.

Probably, in the not distant future, a considerable saving of oil fuel will be effected by the use of specially prepared solid fuels in their place. By selecting coals and by carbonising under these or those conditions, it is possible to produce a series of fuels varying greatly in the readiness with which they burn. The coming shortness of oil fuel will often be met in this way, I believe. Already favourable results have been obtained with Coalite in this direction, using it for the purposes of road traction.

In this account I have dealt advisedly with only one process, because I have had in view the immediate need which faces us of abolishing the smoke nuisance, whilst conserving the volatile matters in coal; also because the process is one with which I am acquainted. To-day there are many active workers in the field and it is to be supposed that, ere long, we shall be in possession of a number of processes each applicable to some special purpose and conditions.

Our Fuel Policy.

Our immediate concern must now be to frame a comprehensive doctrine of Relativity to govern our use of fuel—of the energy at our disposal in coal. Interests must be consolidated, if we are in any way to secure both economy and efficiency. Hitherto, the coal interests have held aloof from every other but have battened upon all. The gas interests have been hopelessly narrow in their outlook. The electrical interests have perforce been developed apart from all others, because no one was wise enough in the beginning to foresee their importance.

The Gas Industry made an irremediable mistake when it failed to adopt the infant Electricity at its birth; its second great mistake was made in despising the movement for the production of a smokeless fuel. The manufacture of gas by methods in any way like those in use at present cannot be much longer an economic proposition: investors will decline to support so isolated an industry.

We have to make up our minds as to how we shall be fed with energy in future; I believe we need it in all the four forms of Electricity, Gas, Liquid Fuel and Solid Smokeless Fuel.

Co-operative organisations must be developed for the supply of all these four forms. The Germans have long since recognised that the by-products of one branch of manufacture must be made the raw material of another—that nothing may be wasted and that materials should be used in a progressive economic order.

Our primary unit being coal, we must first take from it the volatile constituents—gas and oil; then use the residue either as solid fuel or after complete gasification.

As an illuminant for domestic use, electricity stands unrivalled and its use should be universal. As time goes on we shall also use it more and more to assist us in our household work. It is also a superlative means of transmitting power on a large scale.

Glowing coal has a beauty and charm of surface which no clay-begotten gas fire can ever exhibit—and it creates an atmosphere of health such as gas and central heating cannot give. I feel sure that Ruskin would never have brooked the presence of a gas stove—he would have put his foot through it. I believe that all who can will continue to worship the Sun by the sacrifice of suitably carbonised coal on the domestic hearth. The Power-Works in or near to each city must therefore be prepared to supply such a fuel.

The convenience of gas is so great that many, sacrificing their aesthetic feelings, if they have any, will prefer to use it alone—provided the cost be not prohibitive. Gas, however, is fast reaching a price which must be prohibitive, especially when the cost of maintaining fittings in repair is taken into account: the mantles and burners of to-day are constantly breaking down; honesty is gone out of their manufacture.

The relative cost of gas and solid fuel should also be considered. A ton of good domestic coal, costing say £3 per ton, should afford 30 million British Thermal Heat Units: so that the Coal Therm (100,000 units) would cost about 2½d. The South Metropolitan Gas Co. charges me 10½d. per therm for its gas—probably the best in the country. Perhaps it is worth while to use gas at a cost up to three times the value of the coal therm—so I pay 1½ times, at least, as much for my gas as it is worth.

The sulphur impurity gas carries is most detrimental to plants and to household fittings. Being so much a Radical and also a Chemist, I have to be conservative in some things and so hitherto have had only gas in my house: I have now lost patience with it, however, and would get rid of it at once were it not that electric fittings are so costly. I think not a few of us will be forced back to oil lamps. The same disability affects the gas stove, though perhaps not to the same extent: it is fragile and its efficiency falls off with use to a disturbing extent. Gas too is very easily wasted.

Oil we must have for use in the internal combustion engine. Shortly the Americans will have none to spare and who knows what will be the fate of other sources of supply? We can only get it in quantity from our coal and from oil shales.

If, however, we are to use gaseous fuel on any extended scale in the future, users must be trained not to waste it. Nothing is easier than to have the tap full on; nothing more difficult than to persuade the average person so to adjust the supply that the punishment may fit the crime. Go into any chemical laboratory and notice the Bunsen burners—as a rule, the flames of those not in use will be turned full on and whether full on or not the air supply will rarely be properly adjusted. Probably a third to a half of the gas used in our laboratories is wasted As a teacher, I often sought to make students appreciate this point but rarely with success; and I could never get my staff to see that flames were kept low or turned out when not required. There should be a flash-flame to every burner. Another of my fads was to protest against the waste of water. Notice anyone washing up—the tap is usually left running, not turned off, as it should be, directly the required modicum of water has been delivered. Notice also that in cleansing a vessel, most people fill it with water, then pour out the water and proceed to fill the vessel once more and so on; the washing out is equally well done if only a small quantity of water be used each time.

My desire was, however, not merely to teach students to economise gas and water but especially to lead them to do things in a thoughtful manner—deliberately and with intent. No such training is ever given in the schools and the average student is past thinking when he comes to College. In this as in most other respects, there is no principle of Relativity in our school system; it has nothing to do with practical requirements; but the Scribes will have it so and the public makes no attempt to exercise control. We get what we deserve.

In using coal, excepting perhaps steam pressure at the boiler, practically nothing is measured; in the electrical industry, everything is measured and indicated. The moral plane on which the coal user stands is, therefore, in no way comparable with that of the electrician.

The waste of coal in our households is enormous: the kitchener makes economy impossible and no cook has the vestige of a coal conscience. In works there is the same careless disregard. Messrs. Crosfield and Sons have long had on their staff a fuel manager, who has been of the greatest service in securing not only economy but efficiency. I do not know that any firm has followed their example. Only this last week, however, I have learnt on authority that in a large manufacturing works in which the consumption of coal was under 4,000 tons per week, it has been found possible to save about 1,000 tons per week, merely by turning down taps, as it were.

Coal is our only national asset: if we do not use it wisely, without fail we shall lose our place in the world. It therefore behoves us to make it an object of adoration and care, not as it is at the moment the cause of an entirely inexcusable and wicked strife.

Whatever the rights of the present dispute, we cannot but admit that the miners have seen what must be the ultimate solution of the problem. All such elements of intelligence as we have should be brought together without delay, in considered conference, to devise a rational scheme for its future working and use.

DISCUSSION.

THE CHAIRMAN (Sir Arthur Duckham, K.C.B., M.Inst.C.E.), in opening the discussion, said he was sure all those present had very much appreciated the author's most interesting description of the low temperature carbonisation plant and its products. He thought they would also like to express their appreciation of the splendid work done by Mr. Salisbury Jones and Mr. Parker, whom the author mentioned. Personally he had followed that work very closely and had been much impressed by it; he had visited Barnsley and seen the plant there, and it had been explained to him in great detail. Speaking as an outside engineer, he thought the plant at Barnsley was quite near enough to a commercial, satisfactorily working plant. As the author had said, there were one or two small items in the plant that required improving, but the firm appreciated its defects and he was quite certain the very competent engineer, Mr. Davidson, who was now in charge of the plant, would succeed in remedying them. The great drawback, to his mind, of low temperature carbonisation was that he had never seen—or been convinced that there could be—an absolutely satisfactory balance sheet in connection with that process, and he thought that was the reason why it had not been taken up, and was not being taken up to-day, by the gas industry. The two items to be taken into consideration in connection with the balance sheet in low temperature carbonisation were the value of the semi-coke or coalite and the value of the oils. He had been speaking in that room recently for another Society on the subject of coal as a source of oil supply and he had tried to find a value for low temperature coal oils, as the author called them, but he could not get any really sound value. He had spoken to those connected with low temperature carbonisation plant and had been told that high prices could be obtained for the fuel produced, prices which put the financial balance sheet on a proper footing. He told Mr. Salisbury Jones that if the firm could obtain a good price for the oil and a contract for a long period, and if the public took up the use of the fuel, the firm had a very prosperous future before it. He thought it would be agreed that the oil from a low temperature carbonisation plant should be of good value, and he had great hopes that further development work on that oil would prove it was of the highest value; and he agreed with the author that all coal should be treated before use and the hydrocarbons in the form of oil removed. The fuel produced by low temperature carbonisation was the crux of the whole question to his mind. He had tried it and examined it and compared it with other fuels. On one occasion he imported a ton of it into his own house, together with a ton of another fuel, coke made in a continuously working vertical retort, and about a fortnight afterwards his cook said that if he bought any more of "that black muck" she would leave the house. Therefore he might be prejudiced about it! He thought the question of the fuel was one that required further discussion. The other point on which he was not at one with the author was that he had no great liking for solid fuel but thought the future of this country was with heat units distributed as gas or oil, and light and power units distributed as electricity. He had recently been talking in Sheffield to a very important mining engineer there, who said he was not going to open up his colliery until he could build a colliery with only one railway siding and that only with an inward traffic of pit props; he would have two pipelines out, one for oil and one for gas. That gentleman had the audacity to suggest that he should arrange it for him, but he replied that he would like a little more time to think about it! In conclusion, he wished to emphasise the fact that the balance sheet was the point that required discussion. Every one appreciated the advantages of smokeless fuel and of taking oil out of the coal, and the work that had been done in that direction, and he thought that, as far as their plant was concerned, the Company that had been responsible for that work had reached a practical success, and much praise was due to them.

DR. J. A. HARKER, F.R.S., said that, while he greatly appreciated the extremely interesting account the author had given, particularly of the recent experiments at Barnsley, and the evolution of the process, he thought it was a little unfortunate that the author had not given a more definite answer to that aspect of the question which the Chairman had mentioned, *i.e.*, the balance sheet. Some years ago the Ministry of Munitions were considering, owing to the threats of the submarines, what steps should be taken if this country was obliged to find a substitute for the nitrate of soda imported from Chile, and the problem of the fixation of nitrogen was very prominently before the Ministry at that time. In connection with that it appeared possible that this country might be driven to use a process for fixing nitrogen which would require very large quantities of electric power. In a country where, certainly under war conditions, it was quite impossible to provide that electric power from a large station driven by water, it seemed illogical to

burn coal and destroy, by burning the coal raw in a furnace, that amount of fixed nitrogen which was in the coal and which ought to be recovered. In a station to generate 100,000 k.w. the annual loss of nitrogen would amount to about 25,000 tons of ammonium sulphate. In connection with the possibility of establishing a large power station such as he had mentioned, it was necessary to examine whether, as part of the scheme for that station, carbonisation of the fuel by any of the known processes should be attempted. At that time the question of low temperature carbonisation was very prominently before the public, and the Ministry felt it was a subject which should certainly not be ignored. A Sub-Committee, including Mr. W. R. Cooper, chairman, Sir John Snell, and Mr. Albright—Sir Arthur Duckham was also associated with it—visited Barnsley twice and were given the fullest facilities to see the work that was being carried on there. It was only a large scale experiment at that date, and perhaps the author would agree that it was still only an experiment, whose value was not yet proved. That experiment, however, was of such an important character that it was necessary for the results attained to be understood, and in the course of the Committee's investigations the following facts were ascertained. On a pre-war basis, the claim of the Coalite Company was to take a ton of coal costing about £1 and make about 14 cwt. of coalite from it, of which 12 to 13 cwt. was saleable as lump coalite, the remainder being breeze, which was utilized in the process. The production of a satisfactory balance sheet depended on the 13 cwt. of coalite being sold for the same price as that given for the ton of coal, the by-products obtainable paying for the running of the process and providing the profits. The whole economics of the process would be upset if, as had been pointed out, the price obtained for the by-products was not sufficient for that purpose. On the claims of the Company on a pre-war basis it seemed to him that the point as to whether the balance sheet was satisfactory or not rested on quite a narrow margin of something like 6d. or 1s. a ton. Now that coal to put into the retort was going to cost up to £3 a ton—it might not be quite as much as that on a large scale—did the author expect that the Company would be able to sell the resulting coalite for roughly £4 10s., and to run the process simply on the pre-war lines multiplied by a factor representing the increased price of coal? If that was so, coalite might serve as a low temperature fuel for domestic use, but he could not see that it could have the slightest application to large scale power production. He had hoped that the plant and experience of the Coalite Company would have made it possible to substitute for the fuel costing £1 a ton on a pre-war basis coal costing about 8s. or 9s., and to have an extremely valuable intermediate step, *i.e.*, instead of burning raw coal in a big power station, either to use in the boilers the coalite and the power gas obtained in the process, or to gasify the coalite afterwards and use the whole of the thermal units as gaseous fuel. On the pre-war basis, if it had been possible so to modify the plant, which was then designed solely for making smokeless fuel from a good coal, it might have been possible—with some accompanying disadvantages perhaps—to substitute a more or less low grade coal, such as would be used in a large power station, and do something equally good from the point of view of national economy. The possibility of doing that seemed much more remote with coal at its present price. There was no doubt, however, from the evidence collected by the Nitrogen Products Committee, some of which was published in their Report, that the Barnsley experiment was far and away the most serious low temperature carbonisation experiment that had yet been made. When he was at the Bureau of Mines in America he was asked to deal in a lecture to the staff of the Bureau, with the question of the carbonisation of coal as treated in the Report. Some of the experts there were extremely interested in the presentation of the facts as given in that report, and in some additional data he was able to furnish as to the Barnsley scheme. The author's description of the way in which the Barnsley Company had succeeded in overcoming the difficulties outlined was of considerable interest. He wished to congratulate the Company on the progress it had made, but he felt inclined to agree with the Chairman that from many points of view the economics of the scheme were not yet proved.

Mr. J. F. Ward said Mr. Marshall wished to point out that no reference had been made to internally heated coal, in which Mr. Marshall had taken a great interest and in connection with which some experiments had already been carried out. It had not been fully proved that the volatile matter could be condensed from the large amount of producer gas which was necessary to carbonise the coal, but quite sufficient evidence had been forthcoming to show that when suitable condensing arrangements had been made, practically the whole of the condensable hydrocarbon could be obtained. The principal point was that the gas evolved from the producer was not entirely lost but could be used for power purposes, and, if necessary, could be introduced into the retort. Economy of fuel must be considerable in producing the amount of fuel necessary to complete carbonisation and none of the gas used in carbonising was lost if the retort was erected near a power-using works. He thought the method that should be adopted was that which used internally heated rather then externally heated retorts, and in that Mr. Marshall agreed.

MR. A. H. SEABROOK said it was in connection with electric supply that he first began to look into the possibilities of extracting something out of the coal before it was burned under the boilers. He spent a great deal of time on the matter, but he found that on the whole the capital cost and the increased cost of the labour required to run the plant really equalled the value of the products obtained. The particular form of the process in which he had been interested was the Tozer process. A plant to work that process was now being constructed in South Africa and would be finished by about the end of the year, and it would be very interesting to see what results were obtained. The process consisted roughly of the low temperature carbonisation of the fuel first of all and the gasification of the resulting semi-coke, and the firing of boilers with the gas, about 140 or 150 B.T.U. per foot, and the production of calcium carbide. His own experience with fuel carbonised at low temperature was that it was excellent as far as its smokeless qualities were concerned but that it burned very rapidly compared with ordinary coke. He could not see that the producers of the semi-coke were going to get a large price per ton for it, and, as Dr. Barker pointed out, the value of that product was the crux of the whole question. It was no good going to a huge capital expenditure and a huge labour cost, in order to get something out of coal that ought to be got from it, if it could not be done on a satisfactory financial basis.

MR. W. H. PATCHELL said he had spent a good deal of money on low temperature carbonisation and after thoroughly going into the subject he felt obliged to advise those interested in it to drop it and go in for complete gasification. He was very much struck by the sample of coalite shown by the author. When he saw that sample, after looking at the photographs shown on the screen, he wondered where it came from and what special system of selection the author used to pick such a large piece up, because the photographs showed that the coalite was practically all breeze. Some people started to sell low temperature coke and then went on to say that everything must be coked, but everything would not coke. Only a relatively small proportion of coal in this country would coke. A good deal of money had been spent on plant to burn low grade coal for the sake of obtaining the by-products from it, but it would be found that in every case the use of that kind of coal had been abandoned and the best coal obtainable was employed instead. That showed that the difficulty of handling was the crux of the whole question. Now that people could not always get coal and had to burn coke, they appreciated what the people who had tried to burn low grade coal were up against. Further, he did not know whether the "black muck" to which the Chairman had referred was the coalite or the vertical retort coke! In the previous autumn he had tried to get through to see the Smith process used in the States, as that seemed to him one of the most promising systems that had yet been invented. It was a two-stage process. The first stage was to make the coke and the second stage to briquette it. He thought the Company at Barnsley would have to pay serious attention to that process and that they would have to have some kind of briquetting, because low temperature fuels were very friable. Another promising process was the Neilson process, in which the coke was made to stick together while it was in a plastic state instead of being briquetted. There was also another process in the States, which had a kind of movable grate, not depending on gravity, to get the coke out. Some of those processes were exceedingly interesting. He thought some method of making low temperature coke more coherent and easier to transport would have to be adopted in this country.

MR. G. M. GILL, speaking as a gas engineer, said that when the coalite process was first introduced he studied it and thought it was fundamentally wrong as a carbonising process. Very great claims were made on behalf of it at that time and a great deal of money was put into it by the public, much of which was lost. It seemed to him that the great problem in low temperature carbonising was to make a coke which would stand handling, and he did not think there was any process by which it was possible for that to be done, while leaving a considerable proportion of volatile matter still in the coke and only heating it to a comparatively low temperature. In a gasworks the coal was heated to a high temperature, the volatile matter being driven right off, and in the process the coke became harder each extra minute it was carbonised, and in that way it was made strong enough to stand the rough treatment that it received in the ordinary course of handling. Even in that process, with the coke made so hard, something like 10 per cent. of coke dust was obtained. Gas engineers did not agree with the author that their process was inefficient. Out of a ton of coal they obtained about 16 to 17 cwt. of useful products for disposal, of which 4 to 5 cwt. consisted of gas, tar and ammonia products, and 12 to 13 cwt. of coke and coke breeze, the balance of 3 or 4 cwt. as coke, being used for carbonising the coal. It would be seen, therefore, that coke formed the larger portion of the products, and he did not think gas coke ought to be despised at all. It was a fuel that contained a little moisture, ash, and volatile matter, but the vast bulk of it was carbon. It was most suitable for burning in hand-fired boilers, of which there were many thousands in this country. As coke consisted almost entirely of carbon, it was unnecessary to regulate the air when burning

it, after having once fixed the correct quantity, whereas with coal the air ought to be varied from minute to minute, which was of course impracticable. Gas engineers were not at all dissatisfied with their process, but they were quite willing to admit the advantages of low temperature carbonisation when they saw a satisfactory balance sheet obtained from the process. That had not been seen yet, but it might be produced in the future and would be welcomed by gas engineers.

Mr. D. M. Henshaw said he thought the subject of low temperature carbonistaion should be carefully investigated by those who were interested in the matter of coal conservation. He would like to ask the author what amount of ash was contained in the sample of coalite exhibited. The ash content of the coal had a good deal to do with the question whether it could be successfully coked and the coke kept in a condition suitable for transport and then burned, for example, in the domestic fire grate. If the coal had a high ash content, then, no matter what amount of volatile matter was left in the coke, it still had certain disabilities which were inherent in coke of any déscription, in that it made a dusty fire. Dust was perhaps almost as much a drawback to solid fuel as smoke was. Looked at from the standpoint of the producer of fuel oil, he supposed the matter had to be considered from the point of view of the value of that oil now and in the future. If the balance sheet was such that the fuel oil was going to be the product of pre-eminent value, certain coals which were not strictly coking coals might be treated by the low temperature carbonisation process for the production of fuel oil. With regard to the Neilson retort which had been mentioned, that was now in an advanced experimental stage and was distinct from the other processes that had been tried out in this country in that it had the peculiar feature of being heated internally by the sensible heat of producer gas. The producer was linked up in direct connection with the retort, which was an inclined cylinder very similar to a rotary cement kiln, and the coal was allowed to travel slowly down the cylinder by reason of the angle of inclination and the slow rotation of the cylinder. A certain proportion of the semi-coke produced was used in the producer for the production of the producer gas, the gas being led directly from the producer, which was worked at a relatively high temperature, and the coking process was carried out by means of the sensible heat of the producer gas. The gases evolved from the coal were mixed with the producer gas and removed to the upper end of the cylinder. As Dr. Ward had mentioned, the question had yet to be fully established as to what the prospects were of recovering the volatile products from the combined gases and as to what the value of those products would be when recovered in that way. He thought the salient feature of the process was that one did not require a superheated surface, such as was used in the retort which was externally heated, in order to carry out the process of carbonisation. In all forms of externally heated retorts the wall of the retort was naturally of a higher temperature than the material being treated, and he thought experts who had investigated the matter had established the fact that a great deal of the condensable gases which were evolved came directly into contact, when released from the coal, with the superheated surfaces and were cracked or split up, and a great deal of the condensable contents was thus lost. Consequently one might assume that a great proportion of what would be valuable fuel oil or other forms of liquid products was lost in the cracking up stage which thus took place. In conclusion, he wished to say that the paper had been an extremely enjoyable one, and he was sure everyone present was very much indebted to the author for it, particularly for the detailed description given of the process established at Barnsley.

Dr. F. Mollwo Perkin said the paper was a very interesting one, but he was rather sorry the author had confined himself entirely to the one process. As several speakers had mentioned, there were many other low temperature carbonisation processes. There were the Tozer, the Yeadon Whittaker retorts, also the Smith process, which was a dual process, the coke being made first and then briquetted. He was not at all sure that that was not the best process to employ, because, as Mr. Gill had said, in the gas works 10 per cent. of the coke was obtained in the form of breeze, which could be briquetted. Furthermore, if the coke from the low temperature carbonisation process, which was much softer than that produced in a gas works, was briquetted, a very valuable domestic fuel was obtained. At the present moment the binder pitch used for the briquetting was very expensive, but pitch was obtained when either low temperature or high temperature products were being produced. It was rather difficult sometimes to make gas engineers understand that the products obtained by low temperature carbonisation were not the same as those obtained by high temperature carbonisation. It was said that benzol was obtained by low temperature carbonisation, just as it was at a gas works, but that was quite wrong. From the low temperature carbonisation process motor spirit, fuel oil and pitch were obtained, but different products were obtained in the gas works. The coke from the gas works was very much harder, generally speaking, than the coke from the low temperature process. He had recently examined some coke made from coal obtained from some of the Kent collieries, which had been carbonised at 600° C., and the coke was just as hard as ordinary coke obtained from either horizontal or vertical

retorts. In order to increase the quantity of gas produced, gas works had recently been steaming their vertical retorts very heavily, and were thus burning a considerable quantity of their carbon, and as a consequence they obtained a coke which was pretty high in ash, because, owing to the carbon being burned off, naturally the ash content increased. The ash content in any coke depended entirely upon the ash which was in the coal before it was carbonised, whether it was carbonised at high or low temperature. It was an extraordinary thing, however, that very often coal which contained a considerable quantity of ash would, if carbonised, yield large quantities of oil and at the same time give a very useful briquette, which, although it might be ashy, would burn well. It was sometimes said that if the last 12 per cent. in the low temperature coke was distilled off a great deal more oil would be obtained, but that was not so. Gas was obtained and not oil. He had recently been carbonising some peat at a temperature of 500° C., and he obtained 6,000 ft. of gas, which was what he expected to obtain, but when that same peat was carbonised at a temperature of 600° C. it gave between 10,000 and 11,000 cubic ft. of gas and also a larger yield of oil. In gas engineering there was a great deal yet to be learned on the subject of carbonisation: so far, however, this country had led the way in the matter.

The Chairman (Sir Arthur Duckman, K.C.B., M.Inst.C.E.) said there were two points he wished to bring before the meeting. One was the question of briquetting, which was one of the most important, that had to be considered in connection with the handling of fuel. The briquetting of some fuels, such as peat and lignite, was easy, but the briquetting of coal was not so satisfactory, and he had never yet seen a successful method of briquetting coke. He understood, however, that work was being carried out on that subject. The briquetting of any sort of fuel was a very important matter and one that ought to receive careful consideration. He thought those who were concerned with low temperature carbonisation would welcome some method of briquetting the dust that remained behind. The other point he wished to mention was with regard to the work being done at the present time in the removal of ash from coal. If one imagined a low temperature plant working with a more or less ash-free coal one would realise at once the improvement that would be brought about, because it was quite certain that a material like coalite made an ash which was not pleasant to have in a fire grate or wherever it was burned. If those two points were taken into consideration he thought it would be of very great assistance to the development of low temperature fuel and fuel from gas works. The possibilities of a coke which produced practically no ash were to his mind wonderful. Most of those present had heard of the Trent process, the Elmore process and others in that connection, but he did not think success had been achieved by any of those processes, although they provided good groundwork for further development.

Prof. H. E. Armstrong, in replying to the discussion, called attention to a bottle of coal oil he had brought to the meeting, to show how absolutely different it was from coal tar. The oil could be poured easily, almost like water. With regard to the demands that had been made for the balance sheet of the process, it was not for a professor to deal with questions of cost. He had said that the process dated back to the year 1905 but practically it only dated back to a year ago, when plant was set going which produced the magnificent product of which he exhibited a specimen. Mr. Parker did a great work with Mr. Salisbury Jones in showing that low temperature carbonisation was practicable; but he never developed it satisfactorily and his knowledge was largely lost. The first Barnsley experiment was not a practical success; but on the second Barnsley experiment a most remarkable process had been developed, and only minor adjustments were required to bring it to a point when it would be entirely practicable. He did not wish to undertake the discussion of too many subjects at the same time: he had advisedly dealt with the subject from the point of view of the general public only and the use of a material which would make life fairly comfortable in a big city. With regard to the Chairman's statement that in the future gas only would be burned, there was an immense amount to be said for that; but it must be realised that the fight was going to be between gas and coalite. Either gas together with coalite would be used or gas only. The cost of bringing gas into a big city and supplying everyone with it must be taken into consideration, as a very large capital would be required for the mains to give the necessary supply. Personally he did not believe that gas undertakings were going to develop on that scale for a long time to come. The Chairman said that he had tried coalite: if he tried it several years ago it could not have been the same thing as the coalite now produced. Coalite was never made at Barnsley prior to November, 1920. Something was sold before under that name but it all suffered from being over-burned through exposure to the air while it was cooling down. No proper cooling off process was then developed; indeed the invention of that process was the great step forward that had now been taken. The factory at Barnsley was an absolutely smokeless one and afforded a great contrast to a high temperature metallurgical coke works a short distance off. The people of this country had to make up their minds whether or not they were going to make their cities comfortable to live in, and that

could only be done with the aid of smokeless fuel. The question whether they were going to use coalite with gas for cooking purposes or gas only was one that could only be decided in the future. Coalite was quite hard enough for ordinary purposes and it burned in the most perfect manner possible. People ought to be prepared to pay more for it than for coal; it was a better fuel than coal because it did not burn away so rapidly and because it was smokeless. It could be said quite definitely that the minimum value of the oil obtained was that of any similar crude petroleum fuel oil. There was quite enough coal which could be converted into coalite to supply that material for a long time; and quite a large number of small coals, when properly washed, could be improved very much as fuel by conversion into coalite. The specimen he showed was made from a washed coal and probably did not contain more than 5 or 6 per cent. of ash. No coal ought to be used which had not been washed down to that point if a proper fuel were to be produced. It seemed to him that there was no difficulty in getting at the economics of the process: taking the two facts into account—that a superior kind of fuel was obtained and an oil which was certainly at least as valuable as any similar petroleum fuel oil—a fair idea could be obtained of the prospects. In addition, there was a certain amount of motor oil to be got and 5,000 ft. of gas per ton of coal. With reference to the Chairman's friend at Sheffield who proposed to send out his coal as gas, in the case of a town like Sheffield, where gas was largely used, that was the only rational policy to pursue; but London was in an entirely different position. London was further away from the coalfields, although not so far as it was thought to be a few years ago, before the Kent coal had been brought into use. As he had said at the conclusion of his paper, some intelligence must now be used in dealing with the question of the fuels to be employed; people must set to work on the subject so that a proper proportionate system of treatment could be introduced. He thought the gas light companies were now for the third time in a critical position and that they had once more to make up their minds whether they would go into partnership with other interests or not. He did not believe for a moment that when people had once learned to appreciate coalite they would use ordinary coal for domestic purposes. He trusted one result of the present meeting would be that an effort would be made to treat the whole fuel problem in a scientific manner, so that all the various interests might in some way or other be united and dealt with comprehensively.

On the motion of THE CHAIRMAN, seconded by MR. PATCHELL, a hearty vote of thanks was accorded to Prof. Armstrong for his interesting paper, and the meeting then terminated.

GENERAL NOTES.

VICTORIA AND ALBERT MUSEUM.—A selection from the etched work of William Strang, R.A., whose sudden death occurred at Bournemouth on April 12th, has been arranged in Room 132 of the Victoria and Albert Museum. His output was a very large one. The etchings exhibited cannot cover the full range, but deal with the period of his activities from the early 'eighties until 1914. Further examples can also be seen in the Students' Room of the Department of Engraving, Illustration and Design.

DIVIDIVI PRODUCTION IN MEXICO.—Dividivi is a tree native to Mexico from the seeds or pods of which tannin is extracted. Although cheap in price, the tannin obtained from dividivi does not give the best results in the dyeing industry, states the U.S. Assistant Trade Commissioner. This tree, which is known in Mexico under the name of cascalote, reaches a height of from 20 to 30 feet, and grows wild in damp, marshy places. Probably it thrives best in the State of Guerrero. The tannin is found in pods about 3 inches long and ¾ inch broad, which are gathered by peons and transported on mules to the railway. These gatherers receive from 50 centavos to one peso (1 peso equals 2s. 0½d. at par) per day, and the pods are sold at from 16 to 20 centavos per pound. There are no organised methods of gathering and handling the pods. The tree is ready to bear at two years of age, and continues producing until it dies; mature trees yield from 40 to 75 pounds of dry pods annually. The pod, which is dark brown in colour, contains from 40 per cent. to 50 per cent. tannin in its tissues, whereas very little tannin occurs in the seeds. It is estimated that 95 per cent. of the dividivi produced in Mexico is sent to the United States. In the fiscal year ending June 30th, 1914, there were exported from Mexico to the United States 24,000 pounds. Unfortunately statistics of amounts exported for the last few years are not available.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH: TECHNICAL RECORDS OF EXPLOSIVES SUPPLY, 1915-1918.—A special series of reports is being published for the Department of Scientific and Industrial Research in order to make available for the benefit of the industries concerned results of scientific and industrial value contained in the Technical Records of the Department of Explosives Supply of the Ministry of Munitions. The work recorded was done at or in connection with some of the National factories during the war. The preparation of the necessary abstracts and information was begun by the Ministry of Munitions at the close of the war, and arrangements have recently been made by the Department of Scientific and Industrial Research to complete them. The first report in this series, "Recovery

of Sulphuric and Nitric Acids from Acids used in the Manufacture of Explosives; Denitration and Absorption," has now been published by H.M. Stationery Office. The report is divided into the following sections:—Section 1: Description of the Process—1, Denitration; 2, Absorption. Section 2: Plant Design and Operation. Copies of the Report, price 12/6 (by post 13/-), may be obtained through any bookseller or directly from H.M. Stationery Office.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at 8 p.m., unless otherwise announced:—

MAY 11, at 6 p.m.—ALFRED E HAYES General Secretary, English Language Union "Phonoscript: A New Method in the Phonetic Teaching of English Pronunciation." A Demonstration will be given by Scholars from the Infants' Department of an Elementary School.

MAY 25.—DR. C. M. WILSON, "The War and Industrial Peace: an Analysis of Industrial Unrest."

MONDAY, MAY 30.—SIR KENNETH WELDON GOADBY, K.B.E., Medical Referee for Industrial Poisoning, County of London, "Immunity and Industrial Disease."

INDIAN SECTION.

At 4.30 p.m.

FRIDAY, JUNE 10.—SIR GEORGE SEYMOUR CURTIS, K.C.S.I., Member of the Executive Council, Bombay, "The Development of Bombay."

INDIAN AND COLONIAL SECTIONS.

(Joint Meeting.)

At 4.30 p.m

FRIDAY, MAY 27.—SIR CHARLES H BEDFORD, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, MAY 9.. Faraday Society, at the Chemical Society, Burlington House, W., 8 p.m. 1. Messrs. E. K. Rideal and U. R. Evans, "The Problem of the Fuel Cell." 2. Mr. L. F. Knapp, "The Solubility of Small Particles and the Stability of Colloids." 3. Prof. F. G. Donnan, "Note on a Formula Expressing the Variation of Surface Tension with Temperature." 4. Studies in Capillarity. Discussion on the following papers:—"Part I.—Some General Considerations and a Discussion of the Methods of Measuring Interfacial Tensions," by Allan Ferguson. "Part II.—A Modification of the Capillary Tube Method for the Measurement of Surface Tensions," by Allan Ferguson and P. E. Dowson.

Royal Institution, Albemarle Street, W., 5 p.m. General Monthly Meeting.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Graduates' Meeting.) Mr. W. H. Sawyer, "The Engineering Aspect of Modern Iron-Foundry Practice."

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m. Mr. T. A. O'Donahue, "The Valuation of Mineral Properties, with special Reference to Post-War Conditions."

Transport, Institute of, at the Institution of Civil Engineers, Great George Street, S.W., 5.30 p.m. Mr. D. Ross-Johnson, "Water-borne Transport—an Early Form of Traffic Development with specific Relation to Canals and Inland Waterways."

TUESDAY, MAY 10.. Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Prof. P. Carmody, "Trinidad as a Key to the Origin of Petroleum."

Royal Institution, Albemarle Street, W., 3 p.m. Prof. A. Keith, "Darwin's Theory of Man's Origin (in the Light of Present-day Evidence)" (Lecture IV.)

Zoological Society, Regent's Park, N.W., 5.30 p.m. 1. Mr. R. I. Pocock, "The Auditory Bulla and other Cranial Characters in the Mustelidæ (Martens, Badgers, etc.). 2. Mr. G. S. Thapar, "On the Venous System of the Lizard, *Varanus bengalensis* Daud." 3. Dr C. W. Andrews, "Note on the Skull of *Dinotherium giganteum* in the British Museum."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Dr. V. Cornish, "London as an Imperial City."

University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. E. Cohen, "The Metastability of Matter and its Bearing on Chemistry and Physics." (Lecture I.)

WEDNESDAY, MAY 11.. Newcomen Society, Caxton Hall, Westminster, S.W., 5 p.m. Mr. R. Jenkins, "Iron Manufacturers in Sussex." (Part II.)

Oriental Studies, School of, at the London Institution, Finsbury Circus, E.C., 12 o'clock. Miss A. Werner, "European Expansion in Africa." (Lecture III. —"South Africa since 1870.)

Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Mr. H. R. Ricardo, "Some Experiments on Supercharging in a High Speed Engine."

University of London, University College, Gower Street, W.C., 5.15 p.m. Sir Felix Cassel, "Courts Martial."

THURSDAY, MAY 12.. Sociological Society and Regional Association, 65, Belgrave Road, S.W., 8.15 p.m. Prof. P. Geddes, "Co-operation in Social Studies."

Royal Society, Burlington House, W., 4.30 p.m.

Chadwick Public Lecture, 11, Chandos Street, W., 5.15 p.m. Dr. W. Hunter, "Fevers in England, their Prevention and Control." (Lecture II.)

Royal Institution, Albemarle Street, W., 3 p.m. Dr. C. S. Myers, "Psychological Studies." (Lecture II. —"The Appreciation of Music.")

Historical Society, 22, Russell Square, W.C., 5 p.m. Miss C. A. Skeel, "The Council of the West."

University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. E. Cohen, "The Metastability of Matter and its Bearing on Chemistry and Physics." (Lecture II.)

FRIDAY, MAY 13.. Transport, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m.

Royal Institution, Albemarle Street, W., 9 p.m. Mr. W. Bateson, "The Determination of Sex."

Astronomical Society, Burlington House, 5 p.m.

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Mr. J. G. Graves, "The World's Money System."

SATURDAY, MAY 14.. Royal Institute, Albemarle Street, W., 3 p.m. Mr. E. C. C. Baly "Chemical Reaction." (Lecture II.)

Journal of the Royal Society of Arts.

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FRIDAY, MAY 13, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, MAY 4TH, 1921; THE RIGHT HON. VISCOUNT BRYCE, O.M., G.C.V.O., D.C.L., F.R.S., in the chair.

The following candidates were proposed for election as Fellows of the Society:—

Grove, Rev. John, M.A., LL.B., Perth, W. Australia.
Hamidulla Khan, Colonel His Highness Nawabzada Iftikharul-Mulk Mohammed, Bahadur, C.S.I., B.A., Bhopal, India.
Matteson, Herman Howard, M.A., B.S., M.D., Washington, U.S.A.
Oakley, Major Robert McK., V.D., Melbourne, Australia.
Pollard, Harold, London.
Seabrook, A. Hugh, M.I.Mech.E., M.I.E.E., London.
Wretord, Arthur T., London.

The following candidates were balloted for and duly elected Fellows of the Society:—

Brooks, Professor Alfred Mansfield, A.M., Bloomington, Indiana, U.S.A.
Phillips, Trevor Watts, B.Sc., Assoc.M.Inst.C.E., Rock Ferry, Cheshire.

A paper on "Anglo-American Relations: A Personal Impression" was read by Sir GEOFFREY BUTLER, K.B.E., Director of the British Bureau of Information in the U.S.A., 1917-19.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

EIGHTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 20TH, 1921,
THE HON. SIR ARTHUR STANLEY, G.B.E., C.B., M.V.O., in the Chair.

THE CHAIRMAN, in introducing Sir James Cantlie, said that he was well known to all those present. He had done work of much importance before the war, and the work he carried out in the training of V.A.D.'s and others during the war was absolutely beyond all praise. He had now turned his attention to seeing what he could do with men and women of the age of 70. Apparently, from what had appeared in the papers, when one reached the age of 70, with or without the aid of the thyroid gland, one began a new existence. Personally he had been told that Sir James had some young fellows of over 50 capering about London now, who were a terror to those who were not young and to those who were young and thought what an awful fate their old age might have in store for them. He would like to know how to grow old not only with dignity but with force and vigour.

The following papers were then read:—

THOMSON'S MACHINE FOR ARMLESS MEN.

By SIR JAMES CANTLIE, K.B.E., LL.D., F.R.C.S.

During the War Mr. George Thomson, of 105, Granton Road, Edinburgh, bethought himself on seeing a soldier walking past him in the street with his arm in a sling, "I wonder if anything has been invented for a man without any arms at all." He was well aware that many clever contrivances had been devised, and much surgical skill had been expended with marked success upon men who had lost a portion of one or both arms, but he was unable to ascertain whether anything had been invented to help the men who had not even a stump on either arm. Thomson had never seen a man who had lost both arms at the shoulder joint; a man without a stump of any kind to which an artificial apparatus could be adjusted. The pitiable state of a man in such a plight gradually

grew upon him. He pictured one so afflicted as unable to do anything for himself; he could earn his livelihood at no conceivable employment; he could not feed himself; he could not dress or undress; if left in a room with the door closed he could not open it; if called to the closet he had to get some one to accompany him; he could not travel by himself as he could not reach his pocket to pay for his tram or railway ticket; when reading a paper or book he had to get some one to turn over the leaves for him. Even the comfort of smoking was denied him, whether of cigar, cigarette or a pipe, without friendly help; he could not pull his blankets over him when he got into bed; he could not put on, adjust or take off his spectacles; put on a cap or take it off, put on an overcoat or even a cloak if going out by himself; in fact, he was a helpless being, unable to do any one of the thousands of things which make up the important, or even the smallest act that makes up the ordinary—the seemingly trifling—actions of every-day life. He was more handicapped in many ways than the blind man, who by touch could do many actions which to the armless man are denied. Thomson became so possessed with the thought of an armless man's helplessness that he set himself to consider whether any instrument could be devised to alleviate his pitiable state. A gas-fitter by trade, he was acquainted with mechanics and with this knowledge to help him he succeeded in producing a machine—surely one of the cleverest and most original ever devised. Thomson had already invented several mechanisms, and perhaps his apparatus to help the blind is the best known of his many original productions. As he dwelt upon the subject of the armless he came to the conclusion that by the feet alone could any motive power be obtained whereby the hand or arm movements could be imitated.

We are familiar with cases of men born without arms or who have lost the arms doing many things by the feet, such as writing, painting, etc., but Thomson's machine goes far beyond that, and by a mechanism which hitherto, as far as is known, has never been thought of by anyone, and certainly never appeared in the form of a working machine.

My first acquaintance with the machine was made through a letter from Dr. Charles Cathcart, C.B.E., F.R.C.S., Consulting Surgeon to the Royal Infirmary, Edinburgh, and himself the designer of several original surgical apparatus, and well-known as he who introduced Sphagnum Moss as a dressing for wounds during the War. Dr. Cathcart wrote me that he had discovered an inventive genius in Edinburgh—a gas-fitter by trade. He stated that Thomson had devised several clever and original apparatus, but the one that he had just brought out was a "machine for armless men." Dr. Cathcart had brought Thomson and his machine before the Medical Society in Edinburgh, and the members present were much impressed by the machine itself and by the inventive genius of the designer. He mentioned also in his letter that nothing more had come of it, and that the only place where he thought it might be shown in England with the possibility of its being appreciated and made public was at the College of Ambulance in London. I immediately wrote to Dr. Cathcart that I would be pleased to show the apparatus at a series of demonstrations. The result was that Dr. Cathcart came up in December, 1919, bringing Mr. Thomson and his machine for armless men with him.

Three demonstrations were given at the College of Ambulance, one on a Friday afternoon in December, 1919, and a second and third demonstration on the following day (Saturday). The Press were intimated of the meeting on Friday, and many representatives promised to come. The Government, however, got to know of the matter, and as they held a meeting on Friday, at 10 a.m., where Thomson gave a demonstration, the press representatives went there and the subsequent College of Ambulance gatherings in the afternoon and following day were practically neglected by the press. However, appreciative audiences assembled at the three meetings at the College.

Mr. Thomson's demonstrations were of a unique and wholly original character, and all were deeply impressed with the genius of the man. The instrument he employed was made by himself out of old and disused gas pipes, etc., which he was allowed by his employers to make use of. His wages did not allow of his purchasing apparatus, and like many another gifted inventor he had to put up with what he could get to hand.

Mr. Thomson was introduced by Dr. Cathcart, and sitting at a small table

raised some 15 inches from the floor, he proceeded to demonstrate without using his hands in any way whatever. He had never been able to find amongst the soldiers anyone without his upper limbs, so he worked the machine himself as if he had no arms.

The apparatus consists of a small table some 4ft. long and 2½ ft. across, at which he seated himself on a chair. Beneath the table are two rods, on the ends of which (nearest the worker of the instrument) are metal pegs by which the movements are made. The worker removes his boots, and wears socks with a digitation between the big toe and the next, after the nature of a sandal sock or hand mitten with a separate thumb piece. The foot thus covered, the worker places the knobs on the foot rods in these clefts, and by these the movements are made. The foot rods are attached to uprights which are attached to and come up above the side of the table further off the worker. To the top of the upright pieces the "arms" of the apparatus are attached and project towards the worker, coming about half way across the table. The upright pieces are firmly attached to the table and furnished with hinges and joints moveable in almost any direction. The upright parts of the instrument move about like a double-winged gate, and the movements are thus conveyed from the movable foot rods below to the movable arms above.

The ends of the arms, what may be called the "hands" of the apparatus, have a slot in which the various instruments employed for writing, eating food, etc. are inserted and removed as required. These are hung in a rack on the table capable of being reached by the hands. Each of these instruments on the rack has a projecting peg, which, when wanted, is shot into the receiving hole in the hand and removed from the rack ready for use. Thus equipped, the hands are ready for work. A man can perform such acts as eating soup, pudding, etc., with a spoon; can cut meat, potatoes, bread with a knife in one hand and a fork in the other; drink tea from a cup; eat an egg, the worker himself cracking the shell, tearing the "skin" of the egg, and putting salt in the egg from a salt cellar by a spoon, with which he proceeds to eat the egg; pick up a cigarette from the table, put the end in the mouth, open an ordinary box of matches, strike a match on the box and light the cigarette; write with a pencil or pen, fold the paper, put the note in an envelope, stick it down and address it, and put on the stamp; turn over the leaves of a book rapidly, fill in a ledger, write with a type-writer, turn a sewing machine handle, drive a nail into a piece of wood, wash and dry his face and neck, play draughts and execute a number of other movements.

When he had finished the demonstration I said to Mr. Thomson that I could supply him with a patient without arms, this patient of mine, a lad named Witt, who was in the Seamen's Hospital at the Albert Dock Hospital, London. My patient lost both arms at the shoulder joint, being torn off whilst working a rubber machine. His hands and forearms got between the two rollers of the machine, and the limbs were torn off. He was brought to the Albert Dock Hospital. I "trimmed" up the stumps, and though little hope was entertained of his recovery he gradually improved and got well. I informed Mr. Thomson that as soon as he was well enough I would send the lad up to Edinburgh to be trained to use the instrument. I did this in June, 1920, and in ten days he returned (he was, of course, accompanied by a member of his family, to dress, feed him, etc.) In two days' time Thomson tested Witt's progress. He put Witt in a room by himself, setting his dinner on the table—soup, meat, potatoes, etc., pudding and bread—and left him unattended. Witt did everything by himself and finished his dinner.

When Thomson was in London showing the Government Authorities the apparatus he was cordially received, and they hoped to be able to purchase the patent of the machine for £500, but shortly afterwards informed him that the Treasury Department could not see their way to purchase the patent; so I offered to secure the patent for the College of Ambulance. This I accomplished, and the first regulation machine made is deposited there now for public view. My ambition is to provide Witt with an instrument to be used by him at his own home in West Ham, and thereby enable him to have fuller practice and see what he can do to advance other devices which may be of benefit to himself and others.

Poor Witt is sadly handicapped in life. When a boy his health was so poor and his eyes so afflicted that he was not allowed to go to school, so that he can neither read

nor write. He is totally blind in one eye now. Thomson thanked me for sending him to Edinburgh, but said he surely had been given the most difficult case to teach it was possible to conceive; the pupil could not read or write and he was blind in one eye and saw badly with the other. Nothing daunted, however, he set to work, and thereby proved that any one could be taught to work the instrument.

It is impossible to conceive what it means to Witt. Before he was taught he was of little account. He could not dress himself, feed himself, nor read or write—a useless log without hope for the future. Now he is capable of performing the many interesting acts mentioned above. If Thomson had done nothing else, he has given to a helpless man an accomplishment and a gift which brings hope for the future and possibility of providing something for his old age. Many small offerings, by even the poorest, have been sent me to help to buy a machine for Witt to enable him to lay something aside for his old age and to pay Mr. Thomson a tribute of admiration for an invention which has no parallel in the long records of abiding humanitarian work.

AN X-RAY MOTOR-AMBULANCE WAGON FOR USE IN CIVIL LIFE AT HOME AND IN TROPICAL COUNTRIES.

The X-ray wagons were found of considerable value in various seats of war. It is now a question whether they cannot also be used in peace upon a more extended scale with benefit to patient and doctor. In Britain their value has been tested, and the development is being watched with interest. The writer has been privileged to initiate the test in London and its neighbourhood. The idea of utilizing the X-ray motor-ambulance originated in a conversation between Major Robert Mitchell, C.B.E., of the Polytechnic, Regent Street, London; Dr. Robert Knox; and the writer of this note. The furtherance of the idea was rendered possible by the acquisition of an X-ray motor-ambulance which was built by the British Red Cross Society for use in Italy, and now, being no longer required for war purposes, was available for civil work wherever required. Through the influence of Major Mitchell an introduction was obtained to the authorities of the Eccentric Club, Ryder Street, Piccadilly, London, and the writer was placed in touch with Mr. Montague Bates and Mr. Gerald Cripps of that Society. The work of the Eccentric Club during the War is well known; the hostel system in London for the sick and wounded soldiers was founded by the Society and is now a matter of history which will live as a model of practical philanthropy, economically but wisely and liberally conducted, and as a humanitarian work of supreme value.

Among the members of a Club imbued with such feelings and instincts an appeal for help for such a scheme as that put before them found ready listeners and willing helpers. Their help was put into practical shape by a contribution in money sufficient to purchase the wagon; and the British Red Cross Society, at the instigation of Sir Arthur Stanley, K.C.M.G., the Chairman of the Executive Committee of the Society, presented the X-ray equipment. The Eccentric Club presented the wagon to the College of Ambulance, 56, Queen Anne Street, London, W., on the condition that it should be used whenever required in London and the provinces.

No mean gift estimated in monetary value alone, for these wagons have to be specially made for the work required of them, and the equipment is costly, seeing that delicate and fragile apparatus must be so made and protected as to be capable of being conveyed for long distances and over rough roads, it may be, so as to reach their destination.

When the writer was introduced by Mr. Cripps to Mr. Montague Bates at the Eccentric Club he proceeded to give a short account of the purposes to which he proposed to put these wagons. They are none other than that, instead of bringing the injured or sick man to the X-ray apparatus, the apparatus would be brought to him. In place of the injured man being taken from his bed, placed on a stretcher, and conveyed by cab, motor-car, ambulance wagon or train, to where the X-ray picture can be taken, say, in hospital or the private rooms of the X-ray expert, and after the picture is taken having to travel back home again, the X-ray expert and his wagon would proceed to the house and even the room of the patient, and the picture would be taken there without the discomfort and pain involved in the movement, however

carefully done. The wagon stands outside the house, the X-ray apparatus is carried into the house or bedroom, a cable (or lead) from the wagon to the house is taken by the door or through the bedroom window to the apparatus within. It resembles and reminds one of the vacuum cleaner brought to one's door with "the leads" passing by way of a window to the dust-removing machine within.

Mr. Montague Bates listened attentively to the story, and when it was told, he said: "I broke my leg in Cornwall. I was taken to London and occupied a room near the top of a house in Portland Place. I was taken from there upon a stretcher, carried down the narrow stairs from the top of the house and conveyed in a car to the house of the X-ray expert, lifted upon the table, and after the picture was taken had to travel back to my quarters in Portland Place. I shall never forget the agony I suffered during that journey, and in my hope that no one else shall ever be exposed to such torture, I promise you all the support I can give to this humanitarian movement; and although I cannot pledge you that the Committee and members of the Eccentric will also support you, I am of opinion from what I know of them that they will do likewise."

The result of this conversation is known to-day, for the Club has presented an X-ray wagon for public use, and it has already been used for that purpose by the College of Ambulance Authorities.

After settling the X-ray motor-ambulance in its quarters a trial expedition was made to test its mobility and to get the bearers used to handling the contents. The occasion was an ambulance demonstration the writer was giving at Mr. Howard Carter's residence, Ardeley, Stevenage, Herts, 35 miles from London. Dr. H. Marshall Gilbertson, of Hitchin, Herts, some 40 miles from London, saw the announcement in circulars issued in that part of Hertfordshire about the ambulance demonstration and brought a patient with an injured leg to be examined. Although the apparatus was only taken for demonstration and practice, yet we were able there and then to "screen" the leg successfully.

Case I.

Dr. Gilbertson's letter given below best testifies to the appreciation with which the idea of an X-ray apparatus on wheels capable of being taken to any part of the country is regarded. Here is Dr. Gilbertson's letter concerning the matter:—

"Bancroft,
"Hitchin, Herts,
"*October 12th*, 1920.

"Dear Sir James Cantlie,

"I saw from an announcement circulated in this part of Hertfordshire that at the Ambulance Demonstration by the College of Ambulance, London, you were giving at Ardeley Bury on October 9th, 1920, you were bringing an X-ray mobile ambulance with you. I had a case in the heart of the country which required 'screening' or a photograph taken, and so availed myself of the opportunity and brought my patient over, who had injured his leg.

"I was proud to learn that I was the first to make use of this X-ray apparatus. The leg was successfully 'screened,' the injury showing quite plainly. I understand the scheme provides for an X-ray motor-ambulance to visit cases within 50 miles radius of London to be paid for when possible, and given free in cases which cannot afford to pay. As a country practitioner I feel a great responsibility will have been removed if such a splendid scheme can materialise, as in cases of bad fractures and other ailments, especially among the poorer classes, it is absolutely impossible to get the best results without an X-ray photograph.

"I feel sure the idea will find whole-hearted support in the rural districts, both from the medical profession and the public. May I congratulate the Eccentric Club on their foresight and generosity in providing such an up-to-date mobile X-ray wagon?

"Yours sincerely,
(Signed) "H. Marshall Gilbertson,
M.R.C.S., L.R.C.P., London."

In an accompanying note Dr. Gilbertson states that the town of Hitchin, with a population of 14,000 people, has not an X-ray apparatus within its boundaries, and patients have to be sent 40 miles to London to have an X-ray photograph taken. If this is the case in some towns within 50 miles radius of London, how much more is a portable X-ray apparatus likely to be required in the country villages or farmhouses where an accident has occurred and movement would be dangerous or

painful! The X-ray motor would be sent to the village or farm with an expert in X-ray work—a medical expert if possible—free of charge or at a modified charge when patients are poor, while those who are well-off pay for the privilege.

Case II.

An account of the second case attended is recorded in the *Herts and Cambs. Reporter*, of December 31st, 1920, as follows:—

"Buckland, Herts.

"X-Ray Photographic Work Under Difficulties.

"An X-Ray Motor Wagon from London at Buckland.

"On December 21st, the College of Ambulance X-ray motor wagon visited Buckland, Herts, being summoned from London by Dr. Fell, of Buntingford, to visit and report upon a patient of his, named Tobias Rogers. Dr. Fell wrote to his friend, Sir James Cantlie, to whom this wagon was presented by the Eccentric Club for use by the College of Ambulance, that he had a labouring man under his care, who, owing to a fall from his bicycle, had injured his right hip, and that an X-ray picture could alone settle the question of diagnosis. Asking for volunteers from the No. 1 V.A.D., London, Sir James obtained the services of three members of the now famous Detachment, namely: Mr. Fulford, Mr. Whistler, and Mr. Emmanuel, three of the most expert ambulance men in the kingdom, to accompany the wagon and assist at the heavy work entailed. The wagon drew up at the door of Rogers' small cottage in Buckland. The patient was upstairs in a small room with a sloping roof. The staircase was unusually narrow, even for a cottage, and it was doubtful if the four large and heavy boxes containing the apparatus for X-rays could be got upstairs to Rogers' bedroom. Moreover, the staircase itself was fragile to a degree, and, in fact, one of the steps gave way under the bearer's feet. It is usual to lift the patient on to a special table carried in the wagon on which to place the patient whilst the X-ray picture is being taken, but it was impossible here as the room was not big enough to allow of the table being set up. Nothing daunted, Mr. Booker, the expert from Messrs. Watson and Sons, 43, Parker Street, Kingsway, London, W.C. 2, who accompanied the wagon, proceeded to take the picture as the patient lay in his bed, He succeeded in doing so after exercising the greatest patience and skill, and obtained a satisfactory skiagram of the injured thigh bone. Mr. Booker had been engaged during the War at similar work in France, but he stated that never in all his experience had he worked under such seemingly impossible conditions."

Letter from Dr. Fell on the case:—

"Dear Sir James,

"I am extremely grateful to you for sending down the X-ray wagon to examine the condition of Rogers' hip. The radiograph was most interesting, as you have no doubt seen. It is very useful with regard to treatment. It is a most splendid idea having this installation to fall back upon in obscure cases in out-of-the-way country places. You deserve the thanks of all general practitioners who wish to avail themselves of such a valuable aid in cases of injury where the diagnosis is difficult to make.

"Yours, etc.,
"R. W. Fell."

Case III.

The third case the ambulance was called to was a case at Croydon, a patient of Dr. Stanley Melville, Radiologist to St. George's Hospital, London. Dr. Melville wrote the following appreciative letter:—

"9, Chandos Street,
"Cavendish Square, W.,
"*January 3rd*, 1921.

"Dear Sir James Cantlie,

"I am anxious to express not only my own personal gratitude to you, but also my great satisfaction with the X-ray motor ambulance, which you were kind enough to place at my disposal for a journey to Croydon. The patient whom I was asked to examine was very ill, with considerable dyspnœa, and it was of great importance to make the radiographic examination of the chest as definite as possible. The conditions, as you will see, were not good, and yet so excellent was the apparatus and so easy of manipulation that we were able to make a thoroughly satisfactory screen examination and take excellent skiagrams.

"I should like to express my thanks also to the assistants you sent with the ambulance; they were all most willing and helpful and knew their business.

"Hitherto, I have rather dreaded the call for my services at a patient's house; a small pantechnicon was needed, and one had to carry about a battery of accumulators, etc. The motor ambulance has robbed all this of most of its terrors; further, the fact that a plate can be developed in the car itself is a great advantage.

"Yours faithfully,
"STANLEY MELVILLE."

CASE IV.

A journey to Sudbury, Suffolk, some 60 miles from London.

PROPOSED SCOPE OF WORK.

It is intended by the College of Ambulance Authorities to institute centres of the same kind in England, Scotland, Wales and Ireland, so that no part of the kingdom is more than 50 miles away from the benefits likely to accrue from the proximity of an X-ray motor ambulance wagon. Donations for this purpose, or offers to give further ambulances, will be welcomed.

ENGLAND AND WALES.

No. 1.—*London District.*—Middlesex, London, Kent, Sussex (East as far as Brighton), Surrey, Bucks, Herts, Essex, Bedford (South). No. 2.—*Winchester District.*—Hants, Sussex (West), Dorset (East to Weymouth), Wilts (South). No. 3.—*Exeter District.*—Devon, Dorset (West to Weymouth), Somerset (South-west), Cornwall. No. 4.—*Norwich District.*—Norfolk, Suffolk. No. 5.—*Oxford District.*—Oxford, Wilts (North), Northampton (South), Berks, Worcester (South-east), Bucks (North). No. 6.—*Birmingham District.*—Warwick, Worcester, Stafford (South), Leicester (South-east), Northampton (East). No. 7.—*Gloucester District.*—Gloucester (Central and West), Monmouth, Glamorgan (East), Hereford (South), Brecknock (East). No. 8.—*Carmarthen District.*—Carmarthen, Pembroke, Cardigan, Glamorgan (North), Brecknock (West). No. 9.—*Shrewsbury District.*—Shropshire, Hereford (North), Montgomery, Stafford (West), Radnor (North). No. 10.—*Denbigh District.*—Carnarvon, Merioneth, Flint, Cheshire (West). No. 11.—*Manchester District.*—Cheshire (East), Lancashire (South), York, S.W. No. 12.—*Nottingham District.* Nottingham, Derby, Lincoln (Central), Leicester (North). No. 13.—*Leeds District.*—Lincoln (North), Yorks (Central) and East). No. 14.—*Durham District.*—Yorks (North), Northumberland, Durham. No. 15.—*Penrith District.*—Westmorland, Cumberland, Lancashire (North).

SCOTLAND.

No. 1.—*Edinburgh District.*—Counties of:—Edinburgh, Linlithgow, Haddington, Berwick, Selkirk, Roxburgh (East), Peebles. No. 2.—*Dumfries District.*—Dumfries, Ayr (South), Roxburgh (West), Kirkcudbright, Wigtown. No. 3.—*Glasgow District.*—Lanark, Ayr (North), Stirling, Dumbarton, Renfrew, Argyll (North and East). No. 4.—*Dundee District.*—Perth, Forfar, Fife, Clackmannan, Kinross. No. 5.—*Aberdeen District.*—Aberdeen, Kincadine, Banff. No. 6.—*Inverness District.*—Inverness, Ross, Cromarty, Sutherland, Caithness, Nairn, Elgin.

Several doctors from towns outside London have seen the writer about the scheme here unfolded, and they are already endeavouring to get X-ray motor ambulances to serve districts in Scotland and England for a radius of 50 miles or more around centres where wagons of the kind may be housed. In this way a network of areas could be spread covering all parts of the country which could be served with the X-ray motor-ambulance to the benefit of the medical profession and the lessening of pain and suffering to the people.

LONDON X-RAY AMBULANCE SERVICE.

An X-ray motor ambulance wagon, presented by the Eccentric Club to the College of Ambulance, and equipped by the Red Cross Authorities, is now available for service in London and a wide area around.

The wagon has been thoroughly tested, and its efficiency for practical use in town and country declared by Dr. H. M. Gilbertson, of Hitchin, Herts; Dr. Fell, of Buntingford, Herts; and Stanley Melville, Esq., F.R.C.S., of London.

Accompanying the wagon is an operator and staff of specially trained assistants and ambulance men.

The ambulance is intended primarily for men disabled in the War, and for the sick or injured in civil life who are too ill, or too severely injured to be moved.

Any X-ray specialist—a medical man, of course—can obtain the use of the wagon and himself go to his better-off patients in the country and receive his fees as he would in towns, or he will be able to charge at the rate of consultant medical fees when the patient is at a distance; in this way no practice is lost to the specialist and the motor X-ray expert will thus not be robbed of his just dues.

In hospitals where an X-ray apparatus is to hand it will not be necessary to obtain the wagon, but in private houses and nursing homes in London and in the country where it is dangerous to move the patient, as in fractures of the spine, etc., the College of Ambulance wagon is available at all times.'

Application for Use.

Medical practitioners desiring the services of the X-ray motor ambulance wagon in town or country for patients incapable of being moved from their homes or rooms should apply to the Managing Secretary of the College of Ambulance, 56, Queen Anne Street, Cavendish Square, London, W. 1, by letter, telegram, or telephone (Mayfair 4652), stating the address to which the ambulance is to proceed, the best and most direct road to reach the patient's home, the day and hour at which the ambulance is expected, and such further details as may be required by the Secretary. Telephones should be sent between the hours of 10 a.m. and 6 p.m. The ambulance is available for use on Sundays in urgent cases.

The authorities of the College of Ambulance have not as yet made this work public, as they are testing the possibilities of conveying the delicate apparatus about the country, and whether it can be carried into tiny cottages, up narrow staircases and into diminutive bedrooms. No more severe test could have been set than in that cottage at Buckland, and the College Authorities have now resolved to publish the fact of their being ready to undertake work when and where the wagon may be required.

It cannot be too widely known that the College of Ambulance can be applied to for the services of the wagon anywhere within 50 miles of London. The poor are served without charge, but it is expected of those who can afford it that they will pay fees sufficient to enable this great humanitarian work to be carried on to the relief of the sick and injured. Instead of the injured or sick man being carried to London or elsewhere for examination, the X-ray motor wagon is brought to the house of the patient, where in the patient's room the picture is taken, and the agony from transport by stretcher, ambulance, train, etc., avoided.

Uses in Tropics.

If in England these wagons are necessary, how much more in parts of our Empire where the distances are great, where means of conveyance are limited and few and far between, the practical use of a wagon of this sort is at once apparent. Where roads are rough it will not hinder the wagon getting along, nor will the apparatus be thereby injured. It is so carefully made that it can stand bumps and jolts with impunity, and as the wagon at the College of Ambulance was intended for the rough hill roads in northern Italy, it will stand almost any rugged road. Where no road exists, as in the interior of China and West Africa, the wagon with its contents could be conveyed by boat, or the apparatus could be removed from the wagon and conveyed by boat and hence by bearers to places beyond the river banks.

Overseas, especially in districts where railways are relatively few or altogether absent, where illness is sudden and deadly in its course, where doctors are far apart and special means of diagnosis unattainable, these wagons stoutly built for rough work in desert or hilly countries will be a great factor in contributing to the betterment of the condition of the suffering.

Maintenance.

So far as the College of Ambulance has provided the money for repairs, garage, running expenses, and for the maintenance of the expert staff of workers which it is necessary to have at hand.

The Eccentric Club has set an example to the rest of the nation in a great practical humanitarian movement, and it behoves others to assist in providing the means to allow of the College of Ambulance continuing to maintain so great a public benefit as the X-ray motor ambulance wagon is calculated to bestow.

The Eccentric Club and its Work.

The work of this club is practical: it is immediate in its relief to the

sick and suffering, and its gifts are bestowed with a geniality to which the term "joyous givers" aptly applies. No one who has witnessed their method of raising funds at their meetings and dinners can ever forget that beneath the "bonhomie" of the members there is a deep and earnest feeling that the poor shall not want and the sick and injured shall not suffer as far as it lies within their power to avert it. It is owing to this feeling prevailing amongst the members of the Eccentric Club that this movement to establish X-Ray motor ambulance wagons at home and abroad owes the possibility of its existence, and from what we know of the Club and its work they will take care that the movement shall not be allowed to wither.

ORGANISATION X-RAY SUB-COMMITTEE.

Committee :

LADY CANTLIE, O.B.E.
THE HON. LADY THEODORA DAVIDSON.
SIR JAMES CANTLIE, K.B.E.
GERALD F. CRIPPS, Esq., Eccentric Club.
J. A. HARRISON, Esq., Eccentric Club.
DR. ROBERT KNOX.
STANLEY MELVILLE, ESQ., F.R.C.S.
MAJOR R. MITCHELL, C.B.E. Polytechnic, Regent Street, W.
ERNEST E. HARRISON (*Managing Secretary*, College of Ambulance).

Since the address above, given at the Royal Society of Arts, on April 20th, 1921, the Mayor of St. Marylebone, London, at a largely attended meeting at the College of Ambulance, on April 23rd, 1921, declared the London X-Ray motor ambulance service to be open and ready for work. His Honour heartily commended the great work, and proposed that a cordial vote of thanks be accorded to the Eccentric Club and to the Red Cross authorities for this magnificent gift for public use.

Since the inauguration, the London X-Ray motor wagon has been called upon several times for X-Ray work in private houses, in and around London.

[The Thomson apparatus was exhibited and its uses demonstrated by Mr. W. Witt, an armless man.]

THE CHAIRMAN (The Hon. Sir Arthur Stanley, G.B.E., C.B., M.V.O.) said he was sure all those present had been as interested in the papers as he himself had been. With regard to the second paper, he could not say that he remembered the particular interview with Sir James Cantlie that was there referred to, but it was very similar to many interviews he had with Sir James and Lady Cantlie. Sir James had said that he was very generous, but it was not his own money that he was then giving; it was the money the public subscribed to help the sick and wounded. Whenever Sir James or Lady Cantlie came into the room he realised it was best to give at once what they wanted, for he was always perfectly certain they would obtain it in the end. He was bound to say, however, that they never asked for anythin except in a very good cause. If Sir Jame recommended that a certain thing should be done, he was always certain that it was the best thing that could be done in the interests of the sick and wounded men, for whom the Red Cross was caring at that time.

The X-ray ambulance service was of very great interest. Curiously enough, the place where it had been found of the greatest use was on the Italian front. He did not know whether the Italians had one of the ambulances before the English—they had one either just before or just after. By the end of the war the English had three on the Italian front and the Italians had a considerable number. In the mountainous districts where the Italians were fighting and where there were no towns with an X-ray apparatus, the X-ray motor cars undoubtedly saved innumerable lives and immense suffering. In this country also, in the case of an accident in the street or of a patient in a country cottage, who would suffer agony if he had to be brought down a narrow staircase and conveyed to the nearest town that had an X-ray apparatus, the fact that such people could now be X-rayed on the spot would obviously be of the very greatest value to suffering humanity in the future. In a country such as England, however, where the large towns were very close together, there was not such a very great need for the X-ray motor ambulances as there was in more sparsely populated countries, although, as the author had pointed out, there were many occasions when they could be of the greatest possible value even in this country. He wished to add a word in corroboration of the author's statements about the work of the Eccentric Club. That Club worked quietly and unostentatiously, but whenever there was good work to be done one could be perfectly certain that the Eccentric Club would find the money for it if money was required. With regard to Thomson's apparatus, he was sure everyone present had been intensely interested in it. The thanks of the meeting were due not only to Sir James Cantlie for his patriotic action in taking up the invention and demonstrating its utility, but also to Mr. Witt for his kindnesss in attending the meeting and showing what could be done by the apparatus. He thought some of the finest work done during the war was that carried on by Sir Arthur Pearson at St. Dunstan's, not only because of what Sir Arthur Pearson actually did in

helping the blind men to help themselves but also because he showed them that their case was not hopeless and that, however much disabled a man might be, there was no reason why he should not fit himself to take some useful part in the battle of life. Personally he had been connected with St. Dunstan's from the very beginning. The men there found that it was only a very slight disqualification to be blind; they learned to do many things and found that there were a dozen different careers open to them in which they could prove themselves to be just as useful citizens as other men. That was a very great achievement, and he thought that Thomson by his apparatus and Sir James Cantlie by taking the invention up had earned the gratitude of the nation in the same way as Sir Arthur Pearson had done. A man that he knew very well was very badly wounded in the last days of the war, having both his arms shot off above the elbow. He was able to tell that man, when he saw him in hospital, that there was a man working for the Red Cross in London who had both arms off above the elbow but had so trained himself that he could act as secretary to one of the Red Cross hospitals in London and attend the Board Meetings and actually take notes. The man in hospital would hardly believe it until he saw a letter written by the secretary of the hospital with his artificial arm. Whoever helped to demonstrate that really no degree of disability need prevent a man from being a useful citizen performed a very great service to humanity. For that reason he thanked Mr. Witt very much for attending the meeting; he had shown what a really brave man could do when he was determined to overcome his disqualification. In proposing a hearty vote of thanks to Sir James Cantlie and to Mr. Witt, he wished to say that he was very proud indeed to have been associated during the war with Sir James and Lady Cantlie, who had done such splendid work for the Red Cross.

Sir James Cantlie briefly replied and expressed his thanks to Sir Arthur Stanley for presiding and for all the valuable help he had received from him. The nation owed a deep debt of gratitude to Sir Arthur Stanley for the work he had done for the sick and wounded during the war.

The meeting then terminated.

THE NECESSITY OF UNIVERSITY SLAVONIC STUDIES.

At a recent meeting of the Russian Section of the London Chamber of Commerce, Sir Bernard Pares spoke on the necessity of encouraging Slavonic Studies in British Universities. No one, he said, will dispute our dependence on normal trade relations with the rest of the world, and whenever normal relations with Russia become possible, they will be welcomed with eagerness.

The war and the Russian revolution have shown the necessity of a policy with regard to Russia founded on solid data, only to be obtained by serious study. The treaty of Versailles has called into being a number of Slavonic countries, Czecho-Slovakia, Yugoslavia, and Poland, and it is essential that there should be a reasonable understanding in this country of the conditions with which these new states have to deal. This knowledge can be obtained in no other way than by first-hand study conducted by trained Englishmen. No trade can be conducted, no policy can be carried out with success except by persons trained to their work. The presence of trained Englishmen in a foreign country, is the necessary condition for a cultural friendship between that country and our own. The only instrument for supplying this training is to be found in the British Universities. The University which has the central and the widest responsibility is that of London; and indeed it is for the examinations of London University that those students scattered over the British Empire present themselves, who are unable to attend any course of University teaching.

The method of training for the work described above is that known as Regional Study, i.e., the study not only of the language, but also of the history, laws and institutions, literature, commercial geography and the economic conditions of a given area. This principle, first applied systematically in England for the case of Russia was promptly borrowed by Germany for application to all countries with which she was concerned, and is the principle now followed in the School of Slavonic Studies in London University.

The need of this study has become infinitely greater than before the war. Russia, being always in the past totally understaffed for her technical and professional services, has constantly had to import large numbers of trained men from abroad, principally from Germany. By the revolution, Russia has now been almost denuded of her own professional service and will be compelled to invite from abroad an infinitely larger number of trained public servants than before. The question before us is whether Russia is to be left entirely to a German monopoly, of which the inevitable effects must be plain to everyone. Wholesale transfers of German businesses to Russia are contemplated, as soon as the conditions offer security. It will be evident that the presence of a given number of trained professional Englishmen in Russia would be of infinite value; it is in the field of civil service that the further rivalry of German and Englishman has to be carried out in that country. Meanwhile, all evidence shows that British assistance of

this kind will, to any Russian government that cares for Russia, be more acceptable than German, wherever other conditions are equal; because in our case no monopoly is sought, and because Germans have shown themselves extraordinarily unsuccessful in making their professional assistance agreeable to Russians.

In the past, the Russian government regularly sent a large number of Russian students to complete their studies in Germany. Those who passed through German technical schools naturally on their return instituted German machinery in the Russian factories of which they were later in charge. Throughout the war and the revolution, there has been abundant evidence of a general desire on the part of Russians to set themselves free of this tutelage.

For the above reasons, the training of Englishmen for work in Russia is the key to all other questions concerning our relations with that country. To this fact English opinion has so far shown itself strangely indifferent. While trade relations with Russia have engaged much interest, so far no regard has been shown for the first needs in education of those of our British colony who have returned destitute from that country, and who by their knowledge and instincts are instruments of the first value for the restoration of our interests there. A large portion of the Russian educated class, has sought asylum here, with their children, whose education could be made another valuable instrument for the restoration of our position in Russia. During the war there was a wholesale system in the prisoners' camps in Germany of training Russian prisoners as future commercial travellers for German firms in Russia.

The task of training men and of informing public opinion is naturally centred at the University of London. The School of Slavonic Studies at this University already includes eight teaching posts (as compared with a maximum of two at any other British University) and offers regional instruction on Russia and most other Slavonic countries (Poland, Czecho-Slovakia and Yugoslavia). There are now before the University detailed programmes of study of every recognised stage, for degrees (Pass and Honours), and also for certificates which will be obtainable without matriculation; each of these grades will represent a definite qualification for employment in Slavonic countries.

This work requires the same measure of organisation and of financial support as has been obtained for the similar study of Oriental languages and countries. Instruction in most of the subjects required is already offered, but not on a financial basis which can retain the services of competent scholars.

In particular, attention must be called to the need of a publication fund, which is an essential need if the information at the disposal of the School is to be circulated.

NOTES ON BOOKS.

THE OLD SNUFF HOUSE OF FRIBOURG AND TREYER, 1720-1920. By George Evans. Privately printed.

The date of the first introduction of Tobacco into Europe by Jean Nicot is given as 1560, that of its being first brought into England by Sir John Hawkins as 1565. Sir Walter Raleigh was certainly the first to make smoking popular, and perhaps sufficient evidence of the rapidity of the growth of that popularity is afforded by the fact that King James I. issued his famous but ineffective "Counterblast" in 1604, less than fifty years after the first pipe was smoked in England, probably by Ralph Lane, one of Raleigh's Virginian governors, since he, M. Fairholt tells us in his History of Tobacco, was "the first English smoker." In the seventeenth century the use of tobacco was firmly established, and Mr. Fairholt gives us copious selections from the literature of the period, in which references to smoking are to be found.

At first tobacco was smoked only, though the practice of chewing spread amongst sailors and soldiers. Pipes only were used; Raleigh had a silver pipe, while, as Aubrey tells us, "the ordinary sort made use of a walnut shell and a straw" (like the Cob pipes made from a maize cob, which are, or used to be, common in America.) Cigars, though they must have been known, only came into use much later, and even then were for long regarded as a luxury. Gradually the use of snuff came into fashion, and by the middle of the eighteenth century it certainly may be said to have superseded smoking among fashionable and aristocratic folk. The domination of snuff lasted till, say, the middle of the 19th century, when smoking both pipes and cigars, rapidly increased in favour, until the influence of King Edward VII. as Prince of Wales made the after-dinner cigar a recognised institution, even at public dinners.

In 1674 Sir Christopher Wren, as Crown Surveyor, reported on a building scheme of Panton, the owner of certain property at the north end of the Haymarket, as Mr. Dasent in his recent book on Piccadilly tells us, and among the houses built, a few years later, was the one still occupied by Messrs. Fribourg & Treyer, the "Old Snuff Shop," whose history Mr. Evans chronicles. Inasmuch as the house has been in the same hands since the first quarter of the eighteenth century, the record well deserves notice. In Mr. Dasent's opinion the firm is either the oldest trading business in the West End of London or one of two such businesses, Messrs. Gunter, the pastry-cooks, being the other. Though the firm has always kept its original foreign name, it has been in English hands since 1803, when it was acquired by an ancestor of the author and his two brothers.

The records of such a business are certain to contain much information of historical interest, and Mr. Evans has done well to publish extracts from them. Unfortunately the oldest books of the firm have not been preserved, and the earliest in existence is dated 1764, so that the author cannot give us much before that year.

From an early date in the 18th century the British Tobacco trade was a large one, and an important source of revenue. Its centres were Bristol and Glasgow, where the tobacco from Virginia and the West Indies was landed. London was, however, the centre of the snuff manufacture, and large amounts of tobacco was sent there to be ground into snuff. The business of Fribourg & Treyer was, until recent years, solely that of makers and dealers in snuff, and it is to matters connected with snuff that Mr. Evans book is almost entirely devoted. He tells us that for the first 100 years of the firm's existence the proportion of tobacco and cigars sold was not more than ten per cent. of the quantity of snuff supplied. By 1845 the consumption of snuff had considerably diminished, and after that date, the sale of tobacco for smoking increased with considerable rapidity.

The reputation gained by the firm he attributes largely to the patronage of George IV., who purchased enormous quantities of snuff from them, so much so that when the King died a very large stock had been accumulated. This was taken over by the firm and sold at large prices, one customer, Lord Petersham, buying nearly £75 worth. There appear to have been some forty or fifty different blends of snuff principally made by mixing different sorts of tobacco, but some having various scenting essences added. Much curious information about the manufacture and treatment of snuff is given, for which those interested in the subject may be referred to the book itself. How much snuff was used individually the author finds it difficult to estimate, but he thinks half an ounce per day for individual use would be a moderate estimate, and below the average.

The earlier cigars were sold by weight, and the first date noted for the sale of any is 1800, in which year 2lb. of "Havannah Segars" were sold for £2 12s. 6d.—Fifty of the present "Corona Corona" size or 70 medium sized cigars would go to the lb., so this gives about 50s. a hundred for a good-sized cigar presumably of high quality. Up to 1850 the prices did not greatly increase, but after that date the sales increased and the prices grew. In 1863 cigars were being sold by the hundred, and some of the most expensive had reached £5 and £6 10s. a hundred. From that date up to 1914, prices did not greatly increase and Mr. Evans tells us that his firm "sold, or had for sale even, very few cigars over £8 per 100."

As to quality, our author thinks that the fine cigars of 30 or 35 years ago were better than they are now, and believes that in spite of all the attention that has been paid in recent years by the Havana manufacturers to the production of high grade cigars "on the whole there is no doubt that a better cigar could more easily and more generally be obtained years ago than at the present time."

As to cigarettes, their earliest mention is in 1852, but they were very little sold until 1866, when Russian cigarettes "begin to be freely mentioned."

Enough has, perhaps been said, to show that Mr. Evans has produced a book containing much curious and interesting information, not only about the history of the industry with which he is connected, but also incidentally about the social history of the past two hundred years.

THE SLIDE RULE. By Charles N. Pickworth. Seventeenth Edition. Manchester and London; Emmott & Co., Ltd.

The fact that this text book has now reached its seventeenth edition is sufficient proof of its excellence and popularity. There is no need now to insist on the value of slide rules: new instruments are constantly appearing, such as the "Rietz," the "Precision," the "Universal," and the "Fix," which are improvements, for certain purposes, upon their predecessors. Mr. Pickworth describes the most recent of these, and thus keeps his text book thoroughly up-to-date.

CORRESPONDENCE.

SCIENCE AND THE INVESTIGATION OF CRIME.

In the report of the interesting and valuable paper by Mr. C. A. Mitchell, contained in the *Journal* of April 22nd, it is stated that my "main idea" in regard to finger-print identification was found by me on publication, to have been anticipated by Sir William Herschel. This is quite incorrect. Sir William always conceded to me priority of publication as to finger-prints generally, and there is nothing to show that he had ever grasped my "main idea," which was to compare with scientific precision prints of the ten-fingers of a suspect in custody (in their proper *serial order*), with those on official records of a former convict. This is general. I felt confident before I published a scrap on the subject that hundreds of thousands of such records could be compared easily by my syllabic method, naming each pattern (as in ab-ra-ca-da-bra, etc.), each set of prints falling into its alphabetic place in the official dictionary. Identification would then, I venture to prophesy, be infallibly secured on the basis of arithmetical permutations.

I cannot, to-day, tell what method was used by Herschel in India, for nothing he published ever made it clear, while I have conclusively shown that his collection of finger-prints was almost mythical. This is told in my pamphlet, *The Hidden Hand*, of which only a few copies now remain in print. I shall be happy to send them as far as they go, to any address on receipt of a stamped address (one penny). It refers mainly to the imprint of the hand of one Konia, a kind of seal to a contract in 1858, at which date Sir William's use of finger prints is said to have begun. No finger-print lineations are distinguishable. It is a blurred imprint like the red hand of Ulster, and illustrates a custom common in India and the east which goes back to the later neolithic periods. I cannot see what it had in common with my method of comparing minutely the patterns of each finger tip in order.

HENRY FAULDS.

I should be sorry if Dr. Faulds were to think that I wished to minimise in any way the value of his pioneer work upon the investigation of finger prints. I have read carefully everything published on the subject both by him and Sir William Herschel, and have had friendly correspondence with each of them. The evidence of witnesses still living proves that Sir William Herschel was studying the use of patterns upon the fingers as a means of identification at a date prior to Dr. Faulds' investigation, but the work of Dr. Faulds was much more comprehensive and laid the foundation for the modern systems of identification and classification, whilst the priority of publication belongs unquestionably to him.

My object in drawing the parallel between this case and that of Darwin and Russel Wallace was to point out that this was another instance of two men independently making the same discovery. The honour, therefore, belongs to both, and, if I remember rightly, Dr. Faulds has already stated in print that he is quite willing to concede to Sir William Herschel an equal share in the discovery. Naturally, he objects to his own share in the work being ignored or misrepresented, and as I have already stated I had no intention of doing this in the remarks I made before the Society.

C. AINSWORTH MITCHELL.

THE OPTOPHONE.

As Sir Charles Parsons remarked in the discussion on Dr. Barr's paper in the *Journal* of April 29th, "The principles involved in the Optophone mechanism" are "capable of very great enlargement and elaboration. It provides a beautiful means of linking" the *speaking* sounds as well as the "musical gamut with the *altitude* of the letters."

The vowel letters, as printed in the Orthotype Notation, are not only between the lines, but ascending, as e e e. These marked letters are, as Miss Jameson has said concerning French accents, "a great advantage." They differentiate, for example, between the 3 sounds of the digraph "ea" in bread," "heaven," "leäd" and "earth," words occurring in the Lord's Prayer.

Typewritten lessons or "print reformed" books being used for blind children who cannot spell, would then be in great demand for foreigners, the teaching of Geography, scientific terms and many other educational purposes.

A. DEANE BUTCHER.

GENERAL NOTES.

VICTORIA AND ALBERT MUSEUM POTTERY COLLECTION.—Some interesting additions have been made to the exhibits of the Department of Ceramics at the Victoria and Albert Museum. A valuable gift, presented by Mr. C. H. Campbell, consists of miscellaneous objects selected from a general collection of pottery formed some fifty years ago. Amongst them are a fine blue and white Kutahia bowl and other specimens of Turkish ware of the 16th century, a number of soup tureens in Strasburg and Marseilles faïence and in porcelain from Meissen and other German factories, and two interesting English specimens, a 17th century model of a cradle in Staffordshire slip-ware and a Chelsea porcelain cream jug of the earliest period. Mr. Campbell's gifts are exhibited in Room 138 of the Second Floor of the Museum. In the Loan Court (Room 40), may be seen a case containing selected specimens of Chinese celadon porcelain, attributable to the Sung dynasty (960-1279), lent by a group of friends of the Museum. Amongst them are several "wasters," found on the site of the kilns at Lung-chuan, in the province of Chekiang, and, therefore, of documentary importance. There are also specimens showing the beautiful glaze of bluish tone of the "Kinuta' class, so named after a celebrated vase in an ancient Japanese temple which in shape resembles a mallet (*Kinuta*).

HYDROELECTRIC VACATION COURSE AT GRENOBLE.—The University of Grenoble has, for many years, made a special feature of instruction in water-power and power transmission. A series of Vacation Lectures with visits to some of the numerous installations in the neighbourhood will be held this summer. The hydro-electro technical course will in all probability be started towards the 8th or 10th August, and will extend over a period of four weeks. The Registration fee for this course

will be Frs. 110 (£2). Further particulars of the course are to be obtained from Mr. H. Sloog, Hon. Sec., British Bureau, Office National des Universités et Ecoles Francaises, Engineering Dept., 45, Great Marlborough Street, W. 1.

International Exhibition at Belgrade, 1921.—An international exhibition will be opened at Belgrade next June, under the auspices of the Museum of Industry and Commerce of that city. The Servian government have placed at the disposal of the promoters an area of 20,000 square metres (about five acres). and the necessary work is in progress.

Water Power from the Rhone.—The Rhone from the Swiss frontier to the sea, is capable of supplying motive power on a large scale, if only its resources were tapped. It is estimated that if all the French waterways were utilized, nine million horse power could be generated, of which the Rhone would furnish 1¾ million horse power. Plans to create power plant on a large scale, were laid down several years ago. As far back as 1902, there was a project to built a station on the upper Rhone capable of generating 200,000 H.P., which could be transmitted to Paris for lighting purposes at a very cheap rate. The Swiss authorities express themselves in complete accord with the scheme, as far as it affects the head waters of the river. The first plant would be erected at Genissat, and the second at Chanaz-Perieux. These would tap the whole of the waters between the source and the last named town.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

At 8 p.m.:—

Wednesday, May 25.—Dr. C. M. Wilson, "The War and Industrial Peace: an Analysis of Industrial Unrest." Sir Robert A. Hadfield, Bt., D.Sc., D.Met., F.R.S., in the Chair.

Monday, May 30.—Sir Kenneth Weldon Goadby, K.B.E., Medical Referee for Industrial Poisoning, County of London, "Immunity and Industrial Disease." The Right Hon. J. R. Clynes, P.C., M.P., in the Chair.

Indian Section.

At 4.30 p.m.

Friday, June 10.—Sir George Seymour Curtis, K.C.S.I., Member of the Executive Council, Bombay, "The Development of Bombay."

Indian and Colonial Sections.

(Joint Meeting.)

At 4.30 p.m.

Friday, May 27.—Sir Charles H. Bedford, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

Tuesday, May 17 .. Royal Institution, Albemarle Street, W., 3 p.m. Mr. E. Clodd, "Occultism." (Lecture I.)
University of London, University College, Gower Street, W.C., 5 p.m. Dr. C. U. A. Kappers, "The Interpretation of the Structure of the Brain." (Lecture II.)
At the London School of Medicine for Women, 8, Hunter Street, W.C., 5 p.m. Mr. J. A. Gardner, "Metabolism of Cholesterol and the Sterols." (Lecture I.)

Wednesday, May 18 .. University of London, South Kensington, S.W., 5.15 p.m. Dr. A. D. Waller and Mr. J. C. Waller. "Experimental Studies in Vegetable Physiology and Vegetable Electricity." (Lecture I.)
Meteorological Society, 70, Victoria Street, S.W., 5 p.m.
Oriental Studies, School of, Finsbury Circus, E.C., 12 o'clock. Miss Alice Werner, "European Expansion in Africa." (Lecture IV.) "British Relations with East Africa up to 1890."

Thursday, May 19 .. Chadwick Public Lecture at the Medical Society, Chandos Street, W., 5.15 p.m. Dr. W. Hunter, "Fevers in England: their Prevention and Control." (Lecture II.)
African Society, Hotel Cecil, Strand, W.C., 9 p.m.
Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Mr. W. M. McGovern, "On the Buddhist Literature in General and its Relation to the Chinese Canon."
British Architects, Royal Institute of, 9, Conduit Street, W., 5 p.m. Mr. R. E. Fry, "Architectural Heresies of a Painter."
University of London, University College, Gower Street, W.C., 5 p.m. Dr. C. V. A. Kappers, "The Interpretation of the Structure of the Brain." (Lecture III.)
Royal Institution, Albemarle Street, W., 3 p.m. Dr. D. S. MacColl, "War Graves and Monuments." (Lecture I.)
Numismatic Society, 22, Russell Square, W.C., 6 p.m.
Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m. 1. Mr. E. H. Clifford, "Scheme for Working the City Deep Mine at a depth of 7,000 feet." 2. Mr. F. P. Caddy, "Stope Measuring at the Passagem Mine of the Gold Mines of Ouro Preto, Ltd." 3. Mr. J. A. P. Gibb, "Notes on some Useful Alignment Charts."

Friday, May 20 .. China Society, at the School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Rev. W. H. Rees, "Scraps of Chinese Humour."
Royal Institution, Albemarle Street, W., 9 p.m. Dr. E. H. Starling, "The Law of the Heart."
University of London, University College, W.C., 5 p.m. Dr. C. V. A. Kappers, "The Interpretation of the Structure of the Brain." (Lecture IV.)
Philological Society, University College, W.C., 5.30 p.m. Mr. C. T. Onions, "Dictionary Evening."

Saturday, May 21 .. Royal Institution, Albemarle Street, W., 3 p.m. Mr. F. Legge, "Gnosticism and the Science of Religions." (Lecture I.)
Municipal and County Engineers, Institution of, S.E. District Meeting at Tonbridge.

Journal of the Royal Society of Arts.

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FRIDAY, MAY 20, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES

NEXT WEEK.

WEDNESDAY, MAY 25TH, at 8 p.m. (Ordinary Meeting.) DR. C. M. WILSON, "The War and Industrial Peace : an Analysis of Industrial Unrest." SIR ROBERT A. HADFIELD, Bt., D.Sc., D.Met., F.R.S., Vice-President of the Society, in the Chair.

FRIDAY, MAY 27TH, at 4.30 p.m. (Joint Meeting of Indian and Colonial Sections.) SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Director, Central Excise Laboratory, India, "Industrial (including Power) Alcohol." The RIGHT HON. LORD SOUTHBOROUGH, G.C.B., G.C.M.G., G.C.V.O., K.C.S.I., in the Chair.

TWENTY-FIRST ORDINARY MEETING.

WEDNESDAY, MAY 11TH, 1921; DR. GEORGE E. MACLEAN, Director of the British Division of the American University Union in Europe, in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Boyd, James, Montmagny, Canada.
Duclos, The Hon. J. A., Port Louis, Mauritius.
Flagner, Harry Harkness, New York City, U.S.A.
Kafuku, R., Osaka, Japan.
Neill, Charles, Singapore, Straits Settlements.
Vernon, The Right Hon. Lord, Derby.
Wilkinson, George Henry, C.C., London.

The following candidates were balloted for and duly elected Fellows of the Society :—

Ahmed, S. A., Howrah, Bengal, India.
Culley, Alexander, London.
Hayashi, Kunizo, Tokyo, Japan.
Livermore, James Edward, Manchester.
Purse, Ben, London.

A paper on "Phonoscript : a New Method in the Teaching of English Pronunciation," was read by MR. ALFRED E. HAYES, General Secretary, English Language Union.

The paper and discussion will be printed in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

SIR GEORGE BIRDWOOD MEMORIAL LECTURE.

FRIDAY, APRIL 22ND, 1921.

THE EARL OF LYTTON, Under-Secretary of State for India, in the chair.

MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, presented the Medal of the Society to Sir Valentine Chirol, for the first Sir George Birdwood Memorial Lecture on "The Enduring Power of Hinduism." Mr. Campbell Swinton explained that in the ordinary course the presentation would have been made at the opening meeting of the present Session in November last, but Sir Valentine had then left for India. Everyone regarded it as very fortunate that the lectures established to perpetuate the memory of Sir George Birdwood, and his devotion to the people of India, should have been inagurated by Sir Valentine Chirol, and that he so happily selected as the subject of his masterly address one with which, as Sir Valentine himself had said, Sir George Birdwood would have been in full sympathy.

THE CHAIRMAN in introducing Lieut.-Colonel Sir Edward Grigg, who had been selected to give the second of the Birdwood lectures, said that the lecturer belonged to a family distinguished in the Indian Service. His father was for many years Director of Public Instruction in Madras, and one of that splendid body of men who, fortunately for this country and fortunately also for India, were to be found in every generation ready to devote their lives to a career of public service in India. Sir Edward was born in India and was therefore brought up in the Indian atmosphere and surrounded by Indian traditions. That was an experience he himself shared with Sir Edward—they were both native-born Indians! Sir Edward had won a reputation for himself as a scholar, as a writer, as a traveller and as a

soldier. He accompanied the Prince of Wales in His Royal Highness' visits to the distant Dominions of the British Empire. With his knowledge of men and of books, his accomplished literary style and his wide sympathy, Sir Edward was very competent to deal with the interesting subject about which he would speak on the present occasion, namely, "The Common Service to the British and Indian Peoples of the World." It should be noted that the title of the lecture was not the services of Great Britain to India or the services of India to Great Britain, nor the comparative services of either to mankind, but the common services of the British and Indian peoples jointly to the world. He believed that Sir Edward would deal chiefly with the past services of those two peoples, but he could not help feeling that, however great those services were in the past, the opportunities in the future for common service to mankind by the British and Indian peoples would be greater than they had ever been in the past. The difficult task of working out a new Constitution in India was proceeding at the present time, but he felt that if, after its accomplishment, the people of India would take their share and play their part in that commonwealth of free nations to which the name of the British Empire had been applied, the opportunities afforded to them of common service to mankind would be practically unlimited.

The lecture delivered was:—

THE COMMON SERVICE OF THE BRITISH AND INDIAN PEOPLES TO THE WORLD.

By Lieut.-Colonel Sir Edward W. M. Grigg, K.C.V.O., C.M.G., D.S.O., M.C.

The lecture which the Royal Society of Arts has invited me to deliver this afternoon was founded in honour of Sir George Birdwood by a wide and very warm circle of friends. We are all here in the first place as a tribute to his life and work, devoted through more than the normal span with splendid warmth of heart and singleness of purpose to the study of India and the welfare of its people. My old friend and chief, Sir Valentine Chirol, delivered the first Birdwood lecture last year. I feel it a very real honour to have been invited to follow him, and I only wish I could give the Society something more worthy of his example and of Sir George Birdwood's memory.

There is no one here, I am sure, who needs to be reminded of Sir George Birdwood's lifelong devotion to Indian history and thought. His knowledge was amazing. His industry never flagged. His enthusiasm burnt in him right up to the end. But what was greatest in him was, I think, his gift of imaginative insight into the Indian point of view and his understanding sympathy with Indian life and ideas. These are enshrined in many wonderful studies of Indian life, some of them fortunately collected in the book which he published not long before he died. A book containing such papers as "A Sunset on Matheran," "The Rajputs in History," or "The Mahratta Plough," deserves a place among the true classics of Anglo-Indian literature such as Tod's "Rajasthan."

The subject of this paper was suggested to me by an eloquent and amusing passage in Birdwood's "Mahratta Plough." That essay, as many will remember, is a wonderful study of the life and methods of a village community in Western India. In the passage which set me to work on this paper, Birdwood is inveighing against our tendency to force Western methods upon an Eastern social organisation to which they are utterly strange, and he quotes as an example an attempt which he himself observed to introduce a steam plough into the agriculture of an Indian State. This is his description of the event:—

"I remember a steam plough being sent to Jamkhandi, one of the Southern Mahratta Native States. It was led out festooned with roses and jasmine, like an Indian Bridegroom, into a rich regar field, and all of us who were called together to witness the prodigies it was to perform, were also wreathed with roses, and touched on our hands and foreheads with atar; and sprinkled all over with rose water. In a moment, with a snort, and a shriek, and a puff of smoky steam, the gigantic mechanism made a vigorous, loud-hissing rush forward, but, as was at once perceived, also gradually downward, until, after vainly struggling for a while against an ignominious fate, it at last foundered in the furrow it had so deeply delved into the soft, yielding soil; and then not all the king's soldiers, and all the king's men, nor all the servants of the incensed Bhavani [Athene Boarmia, the "Ox-yoker" here] the hereditary blacksmiths and carpenters from the neighbouring palatine village, could do anything with the portentous monster. Nothing could be done with it as a steam plough. It had been recklessly brought into a sacrosanct economic system wherein it had no place, except as another god; and another god it was at once made. As soon as it could be moved out of

the field it was sided into the village temple hard by; and there its hugh steel share was set up on end, and bedaubed red, and worshipped as a lingam, the phallic symbol of Siva; and there, I suppose, it stands an object of worship to this day."

The episode is tempting to the moralist, and Birdwood evidently enjoyed his opportunity. The English, he avers, do not sufficiently distinguish between the prosperity of a country and the felicity of its inhabitants. "That men do not live by bread alone," he says, "is one of the truest facts of life in India absolutely hidden from our eyes," and he concludes that "the deepest gulf before England is that we are ourselves digging by forcing the insular institutions of this country on the foreign soil of India—India of the Hindus. That is the special lesson of the English steam plough laid up in divinity in the Jamkhandi State."

To any one whose heart, like that of so many Englishmen, is always half in India, there rings a melancholy warning in Birdwood's parable. It reminded me of Spencer Walpole's summary verdict that "Centuries hence some philosophic historian will relate the history of the British in India as a romantic episode which has had no appreciable effect upon the progress of the human family." My object in this paper is to suggest some considerations by which that verdict should be tempered—or, as I myself hope, reversed. The subject is a large one and I can only attempt a footnote upon it, but I hope that some day this special theme will be taken up with greater knowledge and insight by some British or Indian historian. "In all struggles," once said Sir Charles Napier, "the meanest, if he does his utmost, is of use; the drum boy, eight years old, ought to imagine the battle rests upon himself and his drum." There are so many here to-day with far greater knowledge and experience of India than I, that I beg them to take that passage as describing the spirit in which I attack a subject meet for some far more experienced hand.

To begin with, it is necessary, I fear, to make a present to the critics of British rule in India of many errors of method and judgment aptly symbolised by the Jamkhandi steam plough. Our notions of law and justice, of education, of land tenure, and of popular welfare in general—not to present too large a list—have undoubtedly shown many signs of that mistake. Let us in humility accept the not unsympathetic verdict on this point of a very able Frenchman, M. Joseph Chailley, who studied our Indian system of government with laborious care. Here is his summing up of our legislation:—

"The intentions of the Anglo-Indian legislators were excellent, and their ideas just. They sought to endow India with a certain, and at the same time with a varied, legislation, which should permit of progress, sustain morality, and respect custom; and they have, in large part, succeeded. But they failed to realise that they were giving place too rapidly, and too largely, to the juridical conceptions and procedure of Europe, and they thus compromised the magnificent gift they were bestowing on India."

M. Chailley is probably on equally sure ground when he deals with our justice and our Courts of Law:—

"The English have made the mistake of introducing—in the belief that they were working for progress, and following the dictates of their own conscience rather than the wishes of the natives—guarantees and formalities which involve cost and delays, and which are distasteful to all but a small class of the population."

And he sums up the consequences in a passage of much insight:—

"One is struck by the fact that in India generally, a condemnation passed by a British tribunal is not held by native opinion to involve moral degradation. I do not mean that even on the frontier the natives despise British justice; not at all. They consider it admirable, and prodigious; but not suited to them."

M. Chailley is no doubt right in holding that justice "will never again shelter itself under the oak of St. Louis," in India or elsewhere; but how many of our best district officers have longed, in common with their Indian fellow-subjects, that it might!

Land tenure and land revenue I shall humbly pass by. I suppose we are all agreed in lamenting that Cornwallis rushed in where Akbar feared to tread, and in rejoicing that his example was not followed by Indian Governors elsewhere. One feels that in this problem, where British statesmanship is largely bound by its own acts, Indian

statesmanship is free; and it is perhaps by Indian agency that necessary Indian revenues will be released for the benefit of the Indian people as a whole.

The defects of our educational system in India are another case in point. We can justly remember that our motive was high. The renewal of the East India Company's charter in 1813 contained the stipulation that a lakh of rupees should be spent on education, and when in 1815 the Company's Directors expressed some fear that education might create a political movement dangerous to British ascendancy, Lord Hastings, the Governor-General, replied that we could not betray our principles of government for sordid motives of that kind. Twenty years later Macaulay's arrival upon the Indian scene gave the final impulse and stamp to our educational aims; and there is no denying that in due season we have reaped a rich harvest of superficially educated young men floating discontentedly between two worlds

"—one dead,
The other struggling to be born."

The parable of the steam plough applies to this part of our record with special force.

But though this line of criticism may be true so far as it goes, I venture to say that it represents only a part, and that the lesser part, of the whole truth. Sir George Birdwood himself, who uttered the warning, would never, I am sure, have conceived of applying it to the whole results of British rule in India or of subscribing to Spencer Walpole's facile epitaph on the history of the three centuries which have passed since the seeds of British influence in India were first sown. How then are we to appraise the results of our rule? On the one side there are writers who assume that the steam plough represents all that a wise and docile India needs to ask, and that where the steam plough has failed the failure is due solely to Indian prejudice and incompetence. On the other hand, there are those who believe with Mr. Gandhi that the steam plough has been a steam roller crushing down the real character and value of Indian life.

I am convinced that both these standpoints are essentially false. It is certainly for Englishmen to admit that in India, as elsewhere, they have sometimes let their passion for order and efficiency outrun the need for studying the standpoint and character of those to whom these Western benefits are applied. "I always dread," wrote Sir Thomas Munro to Canning in 1821, "the downright Englishman who will insist on making Anglo-Saxons of the Hindus." On the other hand, we may, I think, justly assume that the philosophic historian will not accept Mr. Gandhi's account of our influence on India without many reserves. It seems to me that neither side approaches the question in a manner likely to arrive at truth. The colonising Englishman is a tremendous power; but India was a country already great in history before the first English ship touched Indian shores. It had been the cradle of two of the five world religions; it had given birth to poets, statesmen, warriors and kings who take rank among the great men of all history; its foremost rulers had made their splendour felt, not only in Asia, but in the Western world; it was a civilisation, distinct from ours, as diverse as Europe in its peoples, and static perhaps in character, but the equal of Europe in many of the higher manifestations of human genius and character. Common-sense, if nothing better, should lead us to suspect that, whatever the results of the close association of Englishmen and Indians during three centuries, that result cannot be attributed wholly to either one people or the other but jointly to both.

All work is of course conditioned by the material in which it is done. A statue carved in marble is necessarily different from a statue cast in bronze. An Indian garden is very different from a garden in the West. The eulogist of British achievements argues that it is not the marble or the bronze or the soil of the garden, but the genius of the sculptor and the skill and care of the gardener, that give the great result. He speaks as though the Indian peoples and the Indian peninsula had merely provided the material in which a heroic political and moral work has been wrought by British genius and efficiency. When I speak of the results of British rule in India as attributable to both peoples, I assign far more than the rôle of passive material to the Indian side. It seems to me as unjust to claim the whole credit for British genius as to deny its fertilising and stimulating effect and to assert that but for British oppression the Indian genius would have flowered immeasurably in the past century. We hear too much of British achievement on the one side and of Indian wrongs on

the other, because so much history seems to be written exclusively either from the British or else from the Indian point of view. When, in contrast to this, I suggest that the main achievement of India in the last century stands to the joint credit of both peoples, British and Indian, in a common account, I mean that Indians as well as British have been an active and essential element in the joint result. The real process has been one of close and constant interaction; it has been due in varying degrees, of which the Indian proportion has grown steadily, to the mind and spirit of both races. When the time comes to appraise the progress of India without racial bias or political prejudice, the philosophic historian will probably find it as hard to assign the credit of the achievement between the two races as to assign between two parents the credit for their child.

Let us endeavour to appraise briefly what the process has been.

I suppose that the final emergence of a conscious purpose in British rule in India may be assigned to the period immediately following the Napoleonic wars. It is quite true that Clive and Warren Hastings, to say nothing of their immediate successors down to Wellesley, often dreamt of an Indian Empire under the British flag and in some ways made the first beginnings of the structure which the 19th century completed; but until the end of the Napoleonic wars we kept our hold on India and took the successive steps by which it was enlarged mainly under pressure of our long struggle for existence with successive European powers. It was only when Napoleon was finally removed from the scene that we took the broad purpose of government in India quite clearly and consciously to our hearts.

What has been the specifically British contribution to Indian development?

In the first place let us do justice to the material side of our work, not all of which has gone the hapless way of the Jamkhandi steam plough. We can point without cheap pride to railways and telegraphs, to canals and irrigation schemes, to the extinction of much cruelty, to the protection of the weak against the strong, to the establishment of a fairer incidence of taxation, to the maintenance of security on coast and frontier and of peace (compared with earlier centuries) within, to the endowment of India for the first time with a system of popular education, and finally to the co-ordination of administration throughout India under a single controlling power. No Asiatic State began to walk this road for half a century after we were well launched on it in India; none has even approached the same high degree of organisation except the island Empire of Japan. In Persia, in Asiatic Russia, in China, in the Dutch East Indies, what is there for comparison? Russia and Holland were the only European Powers with Asiatic possessions at the close of the Napoleonic wars. We need not fear to have the progress of Asiatic Russia or of the Dutch East Indies from 1815 onwards contrasted too favourably, decade by decade, with Indian progress in British hands. Still less need we fear the contrast of Indian development with that of Persia or of China, racked by European feuds and rent by faction and incompetence within.

And here again, in a more important matter than before, I take leave to question the parable of the Jamkhandi steam plough. Birdwood pointed with great truth to the fact that the prosperity of a country is no infallible measure of the felicity of its inhabitants. If our gift to India had been a gift only of material things, it would be hard to deny that we were disturbing a social organisation of almost immemorial antiquity for little real advance in human happiness. But who can suppose that it lay in our power to arrest the contact of East and West? The contact was foredestined, inevitable. India tasted it in its unregulated and competitive form all through the seventeenth and eighteenth centuries. If we had abandoned India after the Napoleonic wars, when the purpose of government first took clear and conscious shape, she would have fallen back an easy prey to the very evils from which our emergence as the predominant power saved her.

Contact between East and West was inevitable. Nothing could arrest the eager and acquisitive spirit of the European pioneers. India lay right across their path, an Eldorado of the Orient, whose wealth was already proved and known. If the British Government had withdrawn, exploitation so far from losing momentum would have gathered it; and in due season, after another era of commercial and military adventure conducted by private enterprise, the British Government would have stepped in again, not because it wished it, but because it had no choice.

Let us admit, then, that European methods and ideals could not have been averted, were they desirable or not. Let us admit that in the zeal of their efficiency the British rulers of India often attempted to go faster and further than was wise. Let us admit that with the material benefit there came new ideas and standards, new methods of justice, new codes of law, profoundly unsettling to the social organisation of the East. Was there really no gift to India in all this except disturbance and unrest?

The answer is surely not in doubt. With our new mechanism of life, with our railways and telegraphs and canals, even with our steam ploughs, we brought to India the great endowment of our own political history, our hard-won knowledge and experience. On the material scaffolding of our Western system of government there has gradually grown up a mental and moral structure which could not have come into being without its aid. There lives and moves a spirit in India to-day, which is Indian through and through, for race-consciousness is of its essence and self-reliance its dearest aim—but that spirit could not have come into being without the mental and moral assimilation of British ideals, sown by British rule. Indian nationalism has a British no less than an Indian parentage. We have given India the communications and the government which have made a nation out of her warring races and states. We have started the impulse which is surely, though very slowly, bridging on the secular side the deep gulf between the creeds. We have sown the ideas of civic responsibility and self-government which are rising now in a mighty harvest all across the Indian scene. We have given this nationalism its language, our language, the only language in which all races of India can communicate and in which their common ideals can take shape. The Indian nationalism of our time is not only the product but the justification of British rule.

We can afford then to let our critics disparage the high Roman fashion in which we have often pursued our aims. We can afford to acknowledge all those errors of method, judgment and understanding which are summed up in the Jamkhandi steam plough. Modern India stands to our credit, whatever our mistakes. The keel and ribs of that new ship, the Indian nation, were laid and riveted by British shipwrights, building with conscious purpose, though even the most far-seeing builded more greatly than he knew.

So much for the British side. What is India's share of parentage? It seems to me a complete mis-reading of the past century of Indian history to suppose that the reaction of India to British rule has been merely the passive reaction of material to a moulding hand. I will try to show why.

In the first place it is essential to recognise that British rule in India would have collapsed at the Mutiny, never to be restored, if it had not enjoyed, not only the blind acquiescence of the masses, but the reasoned support of the higher ranks and castes of the Indian people. Foreign government might have been forced upon India for a time by the power of superior organisation for war; but it would have dealt everywhere with sullen folk, breaking into sporadic revolt and seamed with violence. That has not been the history of British rule. The real Mutiny touched only a strip of Northern India, and even so our moral and fighting power could not have saved the Raj but for the support of a majority of the Indian princes and governing classes, who held firmly to our side. Behind British rule there looms, and has always loomed, the prestige of a great people, who time and again have proved their mettle in Indian wars and whose power encompasses the earth. But this prestige has stood behind the British Raj in India only as the ultimate power of the State stands behind the law in England. It has been a moral power, and the government based upon it has been willingly accepted, with few exceptions, because, on the whole, the feeling and the reason of the Indian people have been steadily upon its side. Let us make no mistake. Indian allegiance to the Raj has been given, broadly speaking, as a reasoned and contented choice. It was so given because those who ruled India before our advent, and those who, under British rule as before it, governed the religious feelings and primitive ideas of its inarticulate millions, broadly approved our character and saw virtue in our aims. But for that reasoned acceptance, which carried with it an almost universal readiness to co-operate, British rule in India would already be a dream of the past. "The Indian people," says Sir Alfred Lyall, "were from the beginning, so far from objecting to the English dominion in India that they co-operated

willingly in promoting it.'' Nor is that true only of the British conquest. The measure and capacity of Indian co-operation grew steadily from the first opening given to Indian ability by Lord William Bentinck in the second and third decades of the nineteenth century right up to its close, when the nationalist movement began to gather strength.

During all that period Indian feeling and Indian opinion exercised an increasing influence upon our policy. The rapid series of annexations, which culminated in the annexation of Oudh, just before the Mutiny, so seriously affected Indian sentiment that they were undoubtedly one of the contributary causes which carried the Sepoy Army into rebellion. As I have already said, Indian loyalty on the whole stood firmly to our cause in that crisis; we should not have weathered the storm, if it had not. But we were wise enough to heed the warning, and call a halt to the policy of annexing Indian States. I do not think that Dalhousie's doctrine of lapse regarding the succession to Indian thrones has ever been revived since that time.

That is only one example of the direct influence of Indian feeling on high policy. An even more important one may be found in the gradual admission of Indians to posts of trust, and more slowly still to posts of responsibility, in Indian government. It is perfectly true that the wisdom and justice of this course was preached from very early times—early in the nineteenth century, for instance, by men like Sir John Malcolm and Sir Thomas Munro.

''We ought to look forward to a time,'' wrote the latter as Governor of Madras in a Minute dated April 27th, 1827,* ''when Natives may be employed in almost every office, however high, and we ought to prepare them gradually for such a change by entrusting them with higher duties from time to time in proportion as experience may prove their being qualified to discharge them. . . Every time that a native is raised to a higher office than had been filled before by any of his countrymen, an impulse will be given to the whole establishment.''

''It is the policy of the British Government,'' he says elsewhere, ''to improve the character of its subjects, and this cannot be done better than by raising them in their own estimation, by employing them in situations both of trust and authority.''

It is well worth remembering that these are the words of a soldier with profound experience of Indian warfare no less than of Indian administration. The last words come from some Memoranda dated 1812-1813.*

I cannot resist one further quotation. It is from his ''Minute on the State of the Country and the Condition of the People,'' dated 31st December, 1814†:—

''When we reflect,'' he writes, ''how much the character of nations has always been influenced by that of Governments, and that some, once the most cultivated, have sunk into barbarism, while others, formerly the rudest, have attained the highest point of civilization, we shall see no reason to doubt that, if we steadily pursue the proper measures, we shall in time so far improve the character of our Indian subjects, as to enable them to govern and protect themselves ''

That was written over a hundred years ago, and who shall say that the faith in it is not being justified?

The faith in India, held by many of our greatest in the Indian Services throughout the century—though, after the Mutiny it suffered a bitter relapse—is in itself the most cogent testimony to the influence of Indian mind and character upon the ideals of British rule. I could quote much from civilian and soldier alike in the same undoubting vein. But the faith of many Englishmen would not have availed against the resistance of their more conservative brethren, had not a constant and increasing pressure for employment in places of trust been maintained by Indians of weight. Every efficient service is hostile to change, and no human organization likes to be overhauled when it is running well. The fitness of Indians for an increasing share in the government of their country was progressively established, and they owe to themselves their success in obtaining it; for it was they who won it, not we who gave. The laurels of that achievement are for India, and only a small minority of Englishmen have any share in them.

I am expressing no sympathy with lawless agitation when I point to the great experiment launched this year as the culminating example of the growth of Indian mind and

* Gleig's *Life of Sir Thomas Munro*, Vol. II., pp. 423-4.

* Gleig's *Life of Sir Thomas Munro*, Vol. II., p. 259.

† Ibid., Vol. III., p. 388.

character during the past century. We are a conservative people, and we make changes in our system only in response to an effective demand for them. It is quite certain, however, that mere sedition would not have moved us to such innovations. We have recognised, and rightly recognised, a powerful but constitutional demand from an educated minority as representing the legitimate aspirations of the Indian people, and now we may justly look to the governing classes in India to support us in arresting sedition which aims at the basis of all government. They have not failed us at need in the past; I do not believe they will fail us now. The great mission just completed by the Duke of Connaught as the representative of the King-Emperor, and the truly understanding note of all his public utterances during the tour, are the surest of all signs to India that the Empire is with her in the loyal aspirations which the new system of government has been devised to fulfil.

The capacity of Indians for high and responsible office under the Crown must be proved by their success in bearing it; but we may look for it with even greater confidence after a century than was shown by Sir Thomas Munro. That the land which bred Asoka and Akbar has statesmanship still in its veins is proved, I think, by the record of many Indians in public service or in public life during the last fifty years. Every Anglo-Indian administrator can think of instances known personally to him, though the best have hitherto served mainly on the judicial side of the Indian Services. I will mention two only amongst those who figured prominently in public life—Sir Syed Ahmed and Mr. Gokhale—neither of whom ever held an official post. A Mohammedan and a Brahmin, they represented widely different strains in Indian history; but they had a common faith in Indian character and a common yearning that it should prove and be approved as fit for the control of its own affairs.

Nor let us forget that Indians have already shown their organising power in the foundation of industries on Indian soil. This is one of the greater fields of expansion and activity just opening before the Indian people, and their pioneers have had to overcome much doubt and criticism, as well as that strong distrust in all schemes of exploitation which has marked the British official in India ever since the Covenanted Service first came into being. I do not know whether such great Indian enterprises as the Tata steel and iron works have yet emerged from the struggling stage; these are times in which industry everywhere has to battle hard for life. But whatever their position, those enterprises are striking testimony to what may be expected of Indian brains and character in this century.

I spoke a few minutes ago of what the English language has done for India. Let us acknowledge that Indians are already repaying this debt. Our language has been permanently enriched by the translations from his own poetry published by Rabindranath Tagore; and there are other English works by Indian writers which promise a new vein in English literature. It is pleasant to see that Mr. Fisher, the Minister for Education, has written a preface to the English poems of Toru Dutt, a gifted young Indian poetess who died very young, collected and re-published by the Oxford Press in the last few days.

The Indian mind has already proved its keenness and its strength in literature, in philosophy, in politics, in law and in industry. There is yet another branch of intellectual activity, distinctively European hitherto, in which the patience and peculiar subtilty of Indian intellect promise great result—I mean, in all forms of scientific research. I believe that Sir Jagadis Chandra Bose already stands very high amongst Fellows of the Royal Society in his contributions to our knowledge of the life of plants; and there will without doubt be many Indian men of science no less talented and industrious to follow in his steps.

I have been seeking to summarise the contribution which Indians have made to their progress under British government during the last century. Let me quote in conclusion an Indian poem from Tagore's *Gitanjali*, since it expresses with touching eloquence the deep yearning and the true character which has brought Indian nationalism to birth as a living and inspiring faith in the present century:—

"Where the mind is without fear and the head is held high;
Where knowledge is free;
Where the world has not been broken up into fragments by narrow domestic walls;
Where words come out from the depth of truth;

Where tireless striving stretches its arms
towards perfection;
Where the clear stream of reason has not
lost its way into the dreary desert sand
of dead habit;
Where the mind is led forward by thee into
ever-widening thought and action—
Into that heaven of freedom, my Father,
let my country awake.'

If the soul of a people is in its songs, those are accents rich in promise for Indian nationalism.

I have tried to analyse the distinctive contributions of British and Indian genius to Indian progress during the past century, and to indicate how striking in its results that joint achievement is. Where British genius has greatly led and inspired, Indian genius has greatly responded and flowered. It is amazing to look at what our joint achievement, the work of a century, means.

In their wonderful union, with all its felicities and with all its pains, the British and Indian peoples have been the pioneers in grappling with the fundamental problems which arise out of the contact between East and West. That problem is not solved. In some ways it grows ever larger as its phases succeed each other and the contact becomes more close; but the peaceful development of India to the point which she has reached to-day, and the increasing response of her leaders to the call for statesmanship in their ranks, is full of promise for the even greater tests which she has still to undergo. The East is static no longer; it is moving faster than the West. But the progress of India in the past century has placed her peacefully in the van of Asiatic States, with no equal in development except Japan; and that fact stands greatly to the credit of her own people as well as ours.

The association of the British and Indian peoples has wrought yet another wonderful result. In spite of their vast diversities, the States and peoples of India have been moulded into one people, owning a common loyalty to one Throne, and moving rapidly towards the recognition of a common destiny. The diversities still exist; but there has never been in Indian history before so wide and comprehensive a sentiment as that which makes the States and Provinces one in fealty to the King-Emperor's Throne. Those who looked forward to the growth of self-government in India a century ago never dreamt that such a destiny could dawn on India as a united whole. The path to be trodden is still difficult and long, but who shall say that the way will not be kept and the goal attained?

There are many elements which must be combined to ensure success. In the first place the time is not yet in sight when Indian unity and security can be maintained without the strong moral fibre of the British Raj. The British Services in India, too, are still the essential cement of the Indian polity; and little true advance will be made unless co-operation is greatly developed between the Indian leaders now taking up the tasks of government and that essentially British system of administration, the purest and most disinterested the world has ever seen. All agitation directed against the structure of our rule attacks, not only the British Empire, but the foundations of Indian nationalism itself, which cannot reach its goal without our protection and our help. There are, of course, elements of danger which are manifest to all; but co-operation has been loyally invited, and it is being as loyally given. In that mutual loyalty of British and Indian administrators, inspired by a common allegiance and a common aim, lies the great hope of our time. Much also must depend upon the Indian Princes, who rule one-third of the soil of India and one quarter of its people. They have to deal with problems of their own, and the policy of British India must always be so shaped as to keep them willing partners in the movement towards self-government of India as a whole. In all these things it is for the British Raj, which has called a new and united India into being, to maintain the structure of unity until Indians can maintain it for themselves.

But while the Raj maintains the structure it has built, the inspiration of Indian policy must pass increasingly to Indian mind. Indians are entitled to demand a government closely identified with Indian feeling, quickly responsive to Indian impulses, Indian in its character and aims, as representative, in fine, of the Indian peoples, as are all British Governments of their own peoples in purely British lands. They are entitled also to desire, as they deserve, a status in the councils of the Empire, and an influence upon its policy, in keeping with India's importance and worth as one of the great Dominions of

the Crown. I spoke just now of united India as a ship wrought by British ship-wrights, who have laid the keel and riveted the frame. Shall I be straining a metaphor too far if I say that Indian nationalism will now be the driving power in the engine-room, while Indian statesmanship shares equally with us the directing power upon the bridge ?

There are people who honestly doubt whether such changes can or should be made ; but do they think that the world stands still ? It was once reported to Carlyle that Margaret Fuller, after much turmoil of soul, had decided to accept the universe. "Gad !" said Carlyle, "she'd better !" There is a salutary moral in that tale.

For, after all, the main arguments against political development in India are arguments which have been used in vain against political development everywhere. Aristotle remarks very sagely somewhere that the only way of learning to play the flute is to play the flute ; and the saying applies completely to the training of citizens for responsible government. Let us not forget that the spread of political responsibility is proceeding faster in the world than ever before.

"The influences," says Lord Bryce, in his just published book on modern democracy, "playing on the mind and habits even of a backward race are now unceasing and pervasive. There is more moving to and fro, more curiosity, more thinking and reading. Changes which it would have needed a century to effect may now come in three or four decades. Superstitions and all else that is rooted in religion hold out longest ; but the habits of deference and obedience to earthly powers can crumble fast, and as they crumble self-reliance grows. Thus the capacity for self-government may be in our time more quickly acquired than experience in the past would give ground for expecting."

No doubt that in this process Western institutions will be adapted and perhaps entirely transformed. There is no reason to believe that the West has any longer a monopoly of the secrets of political growth. With all its virtues, the close association of our Government with the people through district officers has been increasingly impaired ; and there was need of some new elixir to vitalise it and bring it once more into touch with the springs of Indian life. That is for Indian statesmen to achieve. They have the opportunity, and with our co-operation why should we doubt that they will use it, in the long run, both wisely and well ?

I heard an Indian story once of a village girl whose lover was taken from her to the court of an Indian Prince. Often he begged to be allowed to return home ; the Prince was obdurate. But his prayers continued ; and at last the Prince grew weary, and sent him back to his own people—having first cut off the flowing hair and beard which were his pride. The girl came out along the road to meet her lover when he returned ; and as she went, she prayed to Kali that she might make no sign of repulsion on seeing him so disfigured and maimed. And Kali sent a storm with thunder and a fierce lightning-flash, and as the girl turned from her prayer she heard her lover's voice in the road, and suddenly feeling his arms unseen around her, she knew that Kali's lightning had struck her blind. The story does not end there. In due season the girl's blindness was healed, but the healing came slowly, and when at last her sight returned, behold ! her lover's hair and beard were beautiful once more.

I do not want to press the moral of that tale too hard. But there are those who feel that they cannot bear to see the face of the India which they love disfigured, as they think, by change ; and perhaps, if they will pray as that girl and work for India still, their eyes, when they are opened, will not behold the havoc and ruin which they have feared.

I have travelled a long way from the Jamkhandi steam plough. Let us forget it with a smile, sacred, bedaubed and derelict in the Jamkhandi State. The truer parable, as I believe and would have you believe, is that of the ship—His Majesty's Ship "India," the pride of two great peoples, British in her framework, Indian now in her driving-power, taking the waves upon a new commission as momentous for herself, the Empire and the world as any yet entrusted to his British or Indian subjects by the King-Emperor.

DISCUSSION.

THE CHAIRMAN (Lord Lytton), in proposing a vote of thanks to Sir Edward Grigg for his very eloquent, charming, and in every way delightful lecture, said that it was couched in

beautiful language, as those present had every right to expect, and the subject was treated with a breadth of view and an understanding which, he thought, constituted the chief charm of the lecture. Sir Edward had given a most interesting historical résumé of the connection between the British and Indian peoples, and he thought the test of the spirit in which the lecture had been delivered was the mood in which it had left the audience at the end. He was, of course, only speaking for himself, but he felt sure the impression produced upon his mind had also been produced upon the minds of all present. He felt that the mood in which they were left was one of greater readiness to understand and sympathise with features in regard to which they might previously have been impatient or non-understanding, and of less desire than formerly to champion a particular point of view and criticise anything which was inconsistent with it. They felt a greater readiness to believe that even features which they themselves did not recognise as healthy might have a healthy purpose, and he thought they ought to be thankful for the opportunity of listening to a lecture which left them in a mood of that kind. There was only one passage about which he wanted to say a few words, and he selected because it seemed to him to be really the pith and point of the whole lecture. It was the passage in which Sir Edward Grigg reminded the audience that Indian nationalism had a British as well as an Indian parentage. He thought that passage really governed the manner in which the whole subject was treated by the lecturer. Many people held the view that, having conquered India, the British people gave to that country the best form of government and endeavoured to secure, by just administration, the material prosperity of the country, without any other motive than to produce justice, contentment and the material prosperity of the Indian people, and without any other goal before them than the perpetual continuation of such a system. Those who belonged to that school regarded the recent ever-increasing expression of Indian nationalism as merely an ungenerous, impatient hostility to the objects of British rule in India. Personally he believed that that was a profoundly mistaken method of regarding the history of British India, and, as the lecturer had said, it was only if the people of this country understood that Indian nationalism was not only foreseen by British rulers in India but was definitely created by them, and that the goal of Indian nationalism had from the first been the goal of British rule in India, could they feel the same hope and the same faith in regard to the future of India that had actuated Indian Civilians in their work in that country in the past. Only by realising that the unity of India could alone be accomplished within the British Empire and that Indian nationalism had been the goal of British rule in India was it possible for British administrators, in the words that had been quoted in the lecture, "to keep their minds without fear and to hold their heads high."

The Right Hon. Viscount Chelmsford, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., said he only arrived in England two days ago, and on his arrival he found an invitation from the Royal Society of Arts to be present at the meeting that afternoon. He felt it was incumbent upon him to pay some tribute, by his presence, to the great man in whose memory the Sir George Birdwood Lectures had been instituted. He wished to remind those present that the name of Birdwood was not yet dead in India. Only the other day Sir William Birdwood, who was now commanding the Northern Army and resided at Rawal Pindi and Peshawar, was staying with him at Delhi, and he asked Sir William how he found things after his five years' absence at the war. He replied: "I was informed when I returned to India that I should not recognise it as the same place. I used to make it my practice, before I went to the war, always to take my rides about the country and stop in a village, sit down, and have a talk with the village elders or the people round the village well, and listen to their tales. I was told that I should be met now with dour looks and with discourtesy if I did the same thing. All I can tell you is that I have carried out exactly the same practice as I used to carry out in the past. I ride in mufti to the villages all round Rawal Pindi and I meet with the same delightful courtesy and good reception that I always used to experience." A testimony of that kind coming from such a man as Sir William Birdwood was a very valuable antidote to some of the stories that had lately been told about India. It was a far cry from the back blocks of Queensland to the Royal Society of Arts, but the last occasion on which he met the lecturer was when Sir Edward Grigg was his guest in Queensland in 1907 and accompanied him on a duck shoot during the intervals of the work Sir Edward was then carrying out in studying the political situation in Australasia. On that occasion Sir Edward was some way off from the rest of the party and found himself surrounded by what he took to be a herd of wild cattle. Cattle in Australia, as was well known, were always a little suspicious of any one who approached them on foot, because the Australians were generally on horseback. Sir Edward Grigg was on foot, and the cattle came round him in the most friendly way to look at him, but he thought he was being attacked by a herd of wild cattle and the rest of the party heard rapid firing going on, which turned out to be Sir Edward's efforts to preserve himself against the ferocious buffaloes, as he took them to be. He was very glad to see Sir Edward again after so many years, and to find that he

had survived dangers that were much more serious than the Australian cattle. He congratulated Sir Edward on all he had done during the thirteen years that had elapsed, and more especially upon the admirable and delightful lecture he had delivered that afternoon. He (Lord Chelmsford) would like to say a few words with regard to the reforms that had just been instituted in India, because an ounce of fact was worth a ton of theory. He had come straight from the first session of the Indian Legislature, and he had also had an opportunity of seeing how the Legislative Councils throughout the Provinces had been carrying on their work. The experience had been a wonderful one. The sense of balance and responsibility which had been shown by the various Legislatures was a great encouragement to those who always believed that they would show themselves worthy of the trust that had been placed in them. Many difficulties had had to be overcome, and one of the most serious during the past session was a Budget which involved a deficit of something like 19 crores of rupees. People in India did not like taxation any more than English people, and that was a great test of how the new Indian legislators were going to show their sense of responsibility. They had to put extra taxation upon India in order to meet that great deficit and they shouldered the responsibility manfully. Certain taxation proposals were brought forward by the Government, and they very rightly and reasonably criticised some of those proposals and rejected them. They were not material proposals which were rejected, and in the main the whole of the Budget was passed. He thought that was a most encouraging sign. After all, what was well begun was half done, and one might look forward with very great confidence to the sense of balance and responsibility with which the Indian legislators were going to tackle the question of government in the future. The Indian Civil Servant was perhaps the finest Civil Servant in the world, but he had never before had to meet such difficulties as he had had to encounter recently in the Legislatures. He had not been trained to be a debater, he had not been trained to put forward arguments in debate, but the Civil Servant always proved adequate to the occasion. As he had just said, great credit was due to the Indian representatives in the Legislature for the work that they did during the last session, and no less credit was due to the wonderful way in which the Indian Civil Servants rose to the occasion, and, though not practised in debate, were able to put their case fairly and squarely before the Legislature. Time and again Indians who came to see him said: "We cannot understand this at all. We always thought Sir So-and-So and Mr. So-and-so were very hard and very unsympathetic men, but we now come and meet them in the flesh and talk with them, and we find them most sympathetic and ready to see our point of view." The Legislative Assemblies were going to be a great source of education both to the Civil Service and to the Indian legislators, and, speaking only on the educational side, he felt confident that the great adventure that had been made was going to be crowned with success. He wished to second the vote of thanks proposed by the Chairman to Sir Edward Grigg for the very masterly summary he had given of the common service of British and Indians during the past century and for the sympathetic way in which he had dealt with the subject as also for the delightful and felicitous illustrations with which he had charmed his audience throughout the whole of the lecture.

The resolution was carried unanimously.

LIEUT.-COLONEL SIR EDWARD GRIGG, in acknowledging the resolution, said he particularly wished to thank the Chairman and Lord Chelmsford for the very kind remarks they had made about the lecture. He was sure everyone present had heard with delight what Lord Chelmsford had said about the success of the Legislatures in India, and would have noticed particularly that he was able to pay that tribute to both sides of those Legislatures—British as well as Indian, Indian as well as British. That in itself was testimony to the soundness of the hope which he (Sir Edward Grigg) had dealt with in his lecture, and it could not have come from a higher authority than Lord Chelmsford.

SIR CHARLES STUART BAYLEY, G.C.I.E., K.C.S.I. (Chairman of the Indian Section and Member of the Council), wished, on behalf of the Royal Society of Arts, to thank Sir Edward Grigg for his lecture and Lord Lytton for presiding. He felt it would be almost an impertinence for him to say anything about the lecture after what had already been said with regard to it. He was sure there was nobody in the room who had not listened to it with the greatest pleasure and who would not take away with him very valuable food for serious thought. Probably many of those present had taken one side or the other somewhat strongly, though possibly some had been neutral, but he thought the lecture had enabled them all to see both sides of the question in a way that probably very few of them had been able to do before. The Royal Society of Arts was very much indebted to Lord Lytton for taking the chair. Not only had he given up valuable time for the purpose but by his remarks he had added very much to the pleasure of those present, and he had done a very valuable service in helping to establish a tradition that the Chairman at the Sir George Birdwood Lectures should be somebody connected with, interested in, and loving India.

The proceedings then terminated.

NOTES ON BOOKS.

IMMIGRATION AND THE FUTURE. By Frances Kellor, New York: George H. Doran, Company.

Does America want immigration, or does she not? This is a question on which American opinion is sharply divided. Before the war there were already thirty-two races organised in the United States; that is to say, immigrant societies and homes were established there, subsidised by foreign governments; consular officers received increased authority and larger appropriations; and the immigrant had gradually come to look for help from his racial society and his home government rather than to the American authorities. To the man who hoped to see America one solid nation this was a state of things to be deplored, and it has led to the desire on the part of many citizens to stop, or at all events to put severe restrictions upon, immigration. On the other hand, American industries depend to a large extent on immigrant labour. "Immigrant workmen," writes Miss Kellor, "mine three-quarters of the output of coal and iron. They constitute the bulk of labour in the lumber camps. They are used almost exclusively to build our tracks and roads and to keep them in repair. In all forms of construction immigrant labour predominates. The building of houses, delayed first by the war and then by the high price of materials, now finds itself seriously handicapped by the shortage of immigrant labour. Immigrants bake one-half of the bread in America, refine one-half of the sugar, prepare four-fifths of all the leather, make fifty per cent. of the gloves, shoes, and silk, and make ninety-five per cent. of all our clothing. Sixty per cent. of all packing house employers are foreign born."

These figures indicate to what an extent America is dependent upon immigrants for manual labour. But here a further problem arises. The immigrant of to-day, according to Miss Kellor, is very different from the immigrant of pre-war days, and he is not willing to do the kind of work that satisfied his predecessors. The change of attitude may be due to several reasons. He may have become inoculated with Bolshevist doctrines before he left Europe. He may have fought in the war, and consequently expects to find in America something better than the hard manual labour by which he used to live. In any case, he is determined not to overwork himself, and accordingly the employer has to employ considerably more hands than he used to do, and pay them considerably higher wages than were current before the war.

The whole question of immigration into America is extremely complicated. It bristles with controversial points, and the interest aroused in them is evidenced by the immigration bills which have been introduced into Congress since the armistice. To those who desire to understand these points we cordially commend Miss Kellor's book. She is a thoughtful and unprejudiced student of the subject, and presents the case in a clear and scientific manner.

PRINCIPLES OF HUMAN GEOGRAPHY. By Ellsworth Huntington and Sumner W. Cushing, New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd. 21s. net.

Perhaps in no department have the methods of teaching made greater advances during the last twenty or thirty years than in the subject of geography. In many schools the geography lesson used to mean little more than a vain repetition of strings of names—countries and their capitals; counties and their principal towns; rivers, mountains, etc. Geography as it is generally taught now, however, is a very different matter. Geographical features are considered in their relation to man, and thus the subject has come to acquire a human interest even for young children which it sadly lacked a few decades ago.

The present volume is designed to meet the requirements of students who have reached an age when they begin to think for themselves, and to provide normal school students and teachers in elementary schools with a text book to give them a solid grounding in the human relationships which they will be called on to teach. In the first place, the physical background is sketched, special attention being given to the question of climate, the effects of which on human life are all important. Next attention is directed to physiographic environment and its relation to man's activities. This is the portion of the book on which most emphasis is laid, and the authors have succeeded in making it remarkably interesting. The principal industries carried on throughout the world are discussed, together with the reasons for their particular locations. A generous supply of illustrations and charts will help the student to a sound understanding of the text, and give him a very fair idea of the life and conditions of his fellow men in all parts of the world.

A notable feature of the work, and one that should prove specially helpful to teachers, is the list of questions, exercises and problems appended to each chapter. These vary much in difficulty: some are quite simple, and are adapted for quite young children, whilst others are exceedingly difficult and complicated. They are all designed, however, to make the student think for himself, and to impress upon him the value of accurate statistics as opposed to loose generalisations. For those who wish to pursue the subject further, whether as students or teachers, a useful bibliography is given.

Calico Painting and Printing in the East Indies in the XVIIth and XVIIIth Centuries, By G. P. Baker, London: Edward Arnold, 1921. £30.

Those who read the paper by Mr. G. P. Baker on the hand-painted cottons of India, published in the Society's *Journal* five years ago, and still more those who were present at the lecture and saw the specimens then exhibited, will welcome the fine volume he has now given us. The standard of this book is high throughout. The historical and descriptive text is a piece of sound workmanship. The author has laid the foundations well and truly; the structure may perhaps be enlarged in time to come, but it will not need re-building. No labour has been spared, and none wasted, over literary embellishments. The records of the India office, whether published or in the original M.S., have been systematically searched. Moreover, Mr. Baker has brought to the task the experience of a traveller and a practical cotton printer.

The plates are as eloquent a tribute to the fine decorative qualities of the originals as one could wish to have. The reviewer believes them to be as good as any colour reproductions hitherto printed in this country; it may even be asked whether they do not challenge comparison with the best work done in the more famous centres of colour-printing abroad.

These great "pintadoes," as they came to be called from the Portuguese word, were much in demand at home in the latter half of the 17th century. They come frequently into the correspondence of the East India Company, and writers of the time find them worth their notice.

We may not feel very confident that the laborious hand-painting process and the splendid natural dyes used in these old cottons can again be made to serve in a competitive and hard-driven age; but our designers are capable of adapting their work to the conditions of the times, and the synthetic dyer now has to show that, given a fair chance, he can even rival the splendour of these old colours by scientific means.

Mr. Baker is to be congratulated on his rare faith in a demand for book-production of the highest class. The great outlay incurred, and the consequent necessity of putting a stiff price on the volume places it beyond the reach of many who would gladly possess it, but libraries and institutions to which students of design have access may be wise to consider whether they can afford to do without it.

TURPENTINE INDUSTRY IN BRITISH COLUMBIA.

In a recent interview Mr. E. S. Oliver, an industrial chemist and specialist on wood products, who has made a study of methods of extracting the maximum amount of resin from trees without injury to the growing tree, gave some interesting and valuable information in connection with the turpentine industry, which is attracting considerable attention among persons identified with the development of the resources of British Columbia. Mr. Oliver, who has in the past conducted investigations in Mexico and Central America and in the forests of Russia, Sweden, Germany, and the Mediterranean countries, states that the greatest potential source of turpentine and resin chemicals lies in British Columbia.

At a recent session of the provincial legislature there was passed an amendment to the Forest Act, whereby the provincial government is authorised to issue "resin leases" and to collect a royalty of three-quarters of a cent a gallon on all resin gathered in addition to the fees and rentals paid into the Forest Protection Fund. The amendment was passed only after demonstrations by, and reports from, forestry officials, showing that tapping for resin does not injure the growing trees.

Some of the interesting history of this new industry was revealed when Mr. Oliver pointed out that the very first ship which came from England to the shores of America bore instructions, written in the hand of Queen Elizabeth herself, as to the method to be employed in securing tree resin. "And," he added, "curiously enough, on this continent the very same methods are still followed. It is an industry which has shown no improvement in its methods of collecting its raw material."

Under the old system of scarifying the barks of the trees and collecting the resin after the more volatile elements had become oxydised by contact with the air, it was not possible to secure more than 17½ per cent. bulk of turpentine. In Canada the highest production in any of the eastern plants was 15½ per cent. Under Mr. Oliver's tests, the lowest he has received was 33 per cent., or 1 per cent. higher than in Germany, where the resin by-product industry has been developed to an art.

Without disclosing any of the secrets of the process it may be said that Mr. Oliver achieves his results by boring a very small hole into the tree trunk and hermetically sealing it to an air-tight flask. In this way, instead of injury being done to the timber, the growth of the tree is aided. The resin being in the nature of fecal matter which the tree is seeking to rid itself of, the quality of the timber and the rapidity of its growth are aided, the small drain holes not affecting the efforts of the tree to send up sap and build up new cells.

The theory worked out by Mr. Oliver to explain why larches and pines send out resin is that the pines and conifers are the survivors of a cold epoch which swept over the northern hemisphere. The only way in which the germ of life in the tree cell could endure was by the tree evolving a non-freezable and non-swelling substance to enwrap and protect the cells. Such a substance is turpentine, which forms a large element in tree resin. "With a return of warmth," says Mr. Oliver, "these trees now find themselves with a supply of resin for which they no longer have any use. The tree is always seeking to rid itself of the substance by discharging through the roots into the ground and by forming abscesses in the tree trunk. When the tree trunk is scarified or the bark injured the resin oozes out."

Among the valuable products obtained as a result of experiments with British Columbia Douglas fir resins are turpentine, fir oils, which form the base of "fruit" extracts used at soda fountains, medical oils, etc., and resins which make varnishes of the highest grade. Printing inks are also made from the resin. One of the most interesting is Burgundy pitch, which, instead of being "pitch" black, is snowy white. Its greatest value is as a white ink for use in lithographic work.

"The greatest satisfaction," says Mr. Oliver, "is that the industry will be a constructive one, instead of a destructive one as practised in the southern pine forests of the United States. Every tree, no matter how small or how ill shapen, so long as it is healthy, can be made revenue-producing. It will help the lumber industry and will itself become the greatest single industry in the Province."

In reporting the foregoing particulars to his Government, the United States Consul-General at Vancouver states that a local concern has started operations in Cortez Island, at the mouth of Campbell River, about 60 miles from Vancouver, where 20 men are employed. The men now engaged in the work are mostly ranchers residing in that locality, but it is the intention of the Vancouver Company to put on about 200 workmen. The method of pursuing operations is to secure sap rights from private owners. It is estimated that a block of about 100 acres of Douglas fir gives about 800 barrels of pitch per year, or a total of about 40,000 gallons. The rancher is also provided with employment if he so desires, at $5 a day. The majority of the landowners in the Cortez Island and adjacent districts are holding their property for the ultimate timber wealth, but the establishment of this industry is adding much to the value of the forests.

The Company is working on trees not less than 10 inches in diameter. Some of the larger trees are said to yield upward of 40 gallons at the first tapping. The pitch comes forth in colours varying from a bright green and deep red to a milky white. The colour denotes the quality of the product, the bright green being of the highest grade. One gallon of sap produces about one-third gallon of high-grade "turps," while the residue is rich in valuable by-products.

Forestry experts declare the Douglas fir to be the most valuable tree in the world for commercial purposes, not even excepting the rubber tree. The market is also extensive, while the price obtainable for turpentine and other resin products is four times that of pre-war days.

GENERAL NOTES.

Estate Duty. — Information supplied to the Inland Revenue Department for purposes of the Estate Duty shows that the cases where fortunes exceeding a million pounds sterling were left numbered nine in 1918-19; twelve in 1919-20, and eleven in 1920-21. Other large fortunes in the three years mentioned were as follows:—

Not exceeding £	1918-19.	1919-20.	1920-21.
50,000	1,692	1,901	1,755
100,000	439	603	535
500,000	298	366	313
1,000,000	21	30	17

The figures for 1920-21 are in each case provisional. The above table does not represent the number of persons dying in the financial years quoted, but the number of cases in which affidavits were presented to the Department in these financial years. There is necessarily an interval between the death and the presentation of the affidavit.

Indian Census.—According to a telegram from Delhi, the total population of British India and the Native States on March 16th, when the census was taken, amounted to slightly over 319,000,000, as compared with 315,150,000 ten years ago. The increase occurred chiefly in Madras, Bengal, the Punjab, Burma, Assam, and the North-West Frontier Province. Population has decreased in Bombay by 1,800,000, in the United Provinces by 2,600,000, and in Behar and Orissa by 1,400,000. Behar is stationary. Baroda, Mysore and Kashmir show substantial increases, as also do other Native States in Madras, Bengal and the Punjab; the Agencies; and the tribal tracts of the North West Frontier. Decreases have taken place in Hyderabad, Rajputana and Central India.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

At 8 p.m.:—

WEDNESDAY, MAY 25TH.—DR. C. M. WILSON, "The War and Industrial Peace: an Analysis of Industrial Unrest." SIR ROBERT A. HADFIELD, Bt., D.Sc., D.Met., F.R.S., in the Chair.

MONDAY, MAY 30.—SIR KENNETH WELDON GOADBY, K.B.E., Medical Referee for Industrial Poisoning, County of London, "Immunity and Industrial Disease." THE RIGHT HON. J. R. CLYNES, P.C., M.P., in the Chair.

SYNOPSIS.

Industrial Disease may be classified into—A. Primary or intrinsic—due to specific deleterious material handled, such as metallic poisons; B. Secondary or extrinsic—general disease predisposed to by the nature of the occupation, such as tuberculosis. Much is known of cause and prevention of disease processes due to occupation, and very little is known of the essential personal factor of resistance and Immunity to Industrial Disease. Natural Immunity — Acquired Immunity (active and passive). General considerations—Susceptibility, natural, enhanced —Anaphylaxis.

Primary Diseases.—1. Industrial Diseases due to bacterial infections — Evidence — Susceptibility — Immunity. 2. Diseases arising from actual contact with poisonous material — T.N.T., drugs — Susceptibility — Immunity. 3. Diseases arising from dust, fumes and vapours: —Lead, As., Hg., Paint, Dope — Susceptibility and Immunity.

General Considerations.

Secondary Diseases.—A. Bacterial Infections —Tuberculosis. B. Arterio-Sclerosis.

Necessity of more knowledge on the predisposition to diseases of occupation—especially the part played by minor diseases lowering natural immunity. Industrial Disease—a factor in Unemployment. How more knowledge might be gained and Unemployment diminished —Trade Unions and Labour Organisations.

INDIAN SECTION.

At 4.30 p.m.

FRIDAY, JUNE 10.—SIR GEORGE SEYMOUR CURTIS, K.C.S.I., Member of the Executive Council, Bombay, 1916-21, "The Development of Bombay."

INDIAN AND COLONIAL SECTIONS.

(Joint Meeting.)

At 4.30 p.m.

FRIDAY, MAY 27.—SIR CHARLES H. BEDFORD, LL.D., D.Sc., late Director, Central Excise Laboratory for India, "Industrial (including Power) Alcohol."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, MAY 23 .. University of London, at Bedford College for Women, York Gate, N.W., 5 p.m. Dr. G. Macdonald, "The Roman Wall in Scotland." (Lecture I.)

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev. W. St. Clair Tisdall, "The Date of Daniel."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. R. Atkinson, "Cinema Designs."

Geographical Society, 135, New Bond Street, W. 8.30 p.m. Mrs. Rosita Forbes, "Across the Libyan Desert to Kufara."

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C., 5 p.m. "Modern Developments in the Methods of Industrial Assurance Valuations." By Mr. C. W. Kenchington.

East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Mr. H. S. L. Polak, "The East African Indian Problem."

TUESDAY, MAY 24 .. University of London, at the London School of Medicine for Women, 8, Hunter Street, W.C., 5 p.m. Mr. J. A. Gardner, "Metabolism of Cholesterol and the Sterols." (Lecture II.)

Statistical Society, 9, Adelphi Terrace, W.C., 5.15 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Mr. E. Clodd, "Occultism." (Lecture II.)

Post Office Electrical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m.

Linnean Society, Burlington House, W., 3 p.m. Anniversary Meeting.

Photographic Society, 35, Russell Square, W.C. 1., 7 p.m. "Scientific Aspects of Studio Lighting." 1. Mr. L. Gaster, "The Selection and use of Illuminants for the Studio." 2. Mr. J. C. Elvy, "Illumination Problems in Kinematography." Messrs. J. W. P. Walsh and H. Buckley, "Methods of Light Distribution." 4. Mr. I. G. Priest, "A Possible Standard of White Light."

WEDNESDAY, MAY 25 .. University of London, University College, Gower Street, W.C., 5.15 p.m. Dr. A. D. Waller and Mr. J. C. Waller, "Experimental Studies in Vegetable Physiology and Vegetable Electricity." (Lecture II.)

University of London, at Bedford College for Women, York Gate, N.W., 5 p.m. Dr. G. Macdonald, "The Roman Wall in Scotland." (Lecture II.)

Geological Society, Burlington House, W., 5.30 p.m.

Oriental Studies, School of, Finsbury Circus, E.C., 12 o'clock. Miss Alice Werner, "European Expansion in Africa." (Lecture V.) The Partition of Africa.

Electrical Engineers, Institution of, Wireless Section Meeting, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., 6 p.m. Mr. C. F. Elwell, on "Long Distance Wireless Transmission."

THURSDAY, MAY 26 .. Botanic Society, Regent's Park, N.W., 5.30 p.m.

Royal Institution, Albemarle Street, W., 3 p.m. Mr. E. Law "The Architecture and Art of Hampton Court Palace."

Concrete Institute, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr. L. S. White, "Land Subsidence and its Effects on Concrete and other Structures."

FRIDAY, MAY 27 .. Royal Institution, Albemarle Street W., 9 p.m. Mr. E. Mallock, "Elasticity."

University of London, at Bedford College for Women, York Gate, N.W., 5 p.m. Dr. G. Macdonald "The Roman Wall in Scotland." (Lecture III.)

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

SATURDAY, MAY 28 .. Royal Institution, Albemarle Street, W., 3 p.m. Mr. F. Legge, "Gnosticism and the Science of Religions." (Lecture II.)

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FRIDAY, MAY 27, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

NEXT WEEK.

MONDAY, MAY 30TH, at 8 p.m. (Ordinary Meeting.) SIR KENNETH WELDON GOADBY, K.B.E., Medical Referee for Industrial Poisoning, County of London, "Immunity and Industrial Disease." The RIGHT HON. J. R. CLYNES, P.C., M.P., in the Chair.

PROCEEDINGS OF THE SOCIETY.

NINETEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 27TH, 1921.

SIR THOMAS MIDDLETON, K.B.E., C.B., in the Chair.

THE CHAIRMAN, in introducing Sir James Hinchliffe, said that those who were in touch with the industries of this country in the early years of the war soon became aware of a new phenomenon occurring in those industries, that phenomenon being best described as a deep conviction of ignorance. There were obvious reasons for that. The war presented many new problems, and that was perhaps the first determining cause of the feeling of ignorance that grew up, but there was something more—there was on the part of all those who were not able to take service in the field a keen desire to do something more for the country and a feeling of their own lack of capacity to do it. Those two conditions, the obvious demands of the new problems and the discontent people felt with what they were able to do, were responsible for the new awakening. In the later years of the War the movement took shape and resulted finally in the formation of Research Associations for the investigation of the problems connected with the industries of this country. At a recent meeting of the Royal Society of Arts a paper had been read on the subject of those Research Associations by Mr. Abbot, of the Department of Scientific and Industrial Research, the Department primarily responsible for the organisation of those Associations, and on the present occasion Sir James Hinchliffe was going to deal with the activities of a specific Research Association, namely, the Research Association for the Woollen and Worsted Industries, of which Sir James was Chairman.

The following paper was then read:—

THE BRITISH RESEARCH ASSOCIATION FOR THE WOOLLEN AND WORSTED INDUSTRIES.

By SIR JAMES P. HINCHLIFFE, Chairman of the Association.

HISTORY.

The original meetings which eventually led up to the formation of the British Research Association for the Woollen and Worsted Industries were held at the Leeds University, between July, 1915, and May, 1916, when leading manufacturers and textile teachers began to consider the desirability of the establishment of a scheme of education and research for the wool textile trade of the West Riding. In January, 1916, it was unanimously resolved that a small committee be appointed to draw up a scheme of research. That scheme was formulated, and at a meeting held at the County Hall, Wakefield, in the following July, was formally adopted. It was decided in the first instance to hold meetings in all the large centres of production in the West Riding. These meetings were fairly well attended and the support promised was very liberal. At first it was not contemplated that any firms outside the West Riding of Yorkshire should be asked to take part in the movement.

At this particular time there was an organisation in existence—the Textile Institute—which was doing a certain amount

of research work for the Industry, and the Institute had commenced research into the Electrification of Fibres at the Leeds University. That research was taken over by the new West Riding Research Committee and the results have been published. Other researches were started, including :—The Investigations on the effect of Manufacturing Processes on Textile Fibres; Action of Acids, Alkalies and Soaps on Wool; Investigations on Milling, etc; and these have been extended and enlarged upon, as referred to later.

Further, at the Bradford Technical College an investigation was carried out on the comparison of Continental and Noble combed materials as regards the qualities of the cloth produced, and any member of the Association may see the results on application at the College. The general conclusions have been issued in the form of a report.

After we had got our local Association formed in the West Riding, we entered into preliminary negotiations with the Department of Scientific and Industrial Research. The result of that was that Sir Frank Heath, Secretary of the Department, came to Bradford and gave an address to the West Riding Textile Research Association. At this meeting a resolution was passed that we should broaden our scheme and make it an entirely national one. There were many reasons for this, the chief being that it is very undesirable in the national interests that there should be a number of authorities for wool textile research in the country—a position which would lead to over-lapping. Probably, a number of men might be engaged on the same research, and this would not be in the interests of economy. Therefore, it was decided to fall in with the Government scheme and enlarge the West Riding effort so as to include all branches of the woollen and worsted industries in the United Kingdom. The result was that at the end of October, 1917, the Department appointed a Provisional Committee to consider what steps should be taken for the establishment on a permanent basis of a complete national scheme of research for the whole of the British wool-using and closely related industries.

Local representatives of this Provisional Committee secured promises of support from a number of hosiery and other textile firms in the counties of Derbyshire, Leicestershire and Nottinghamshire, while more than fifty firms in Scotland, including nearly all the important firms in the Scotch tweed trade, agreed to join the proposed Association. The Flannel Manufacturers' Association of Rochdale and the Irish Woollen Manufacturers' Association interested themselves in the scheme, and each of these bodies nominated a representative as a member of the Provisional Committee.

The Provisional Committee, which thus included members representative of the industry from all parts of the United Kingdom, submitted its proposals for the consideration of the trade. It had, however, no desire to lay down a rigid scheme, but only to frame an outline to be completed by the British Research Association when this came into existence. When the broader policy was adopted, we transferred about £5,000 from the West Riding funds to the national scheme. Owing to the very generous response in subscriptions and donations, we had previously obtained about £6,000 in the West Riding of Yorkshire alone, and we had spent £1,000 on the researches going forward. A considerable amount of work was necessary in drafting the larger scheme, and the best way was considered to be the floatation of an organisation in the nature of a limited company on a non-profit-sharing basis, to facilitate the negotiation of contracts, etc.

Constitution.

The British Research Association for the Woollen and Worsted Industries was eventually registered on 26th September, 1918, and was approved by the Department of Scientific and Industrial Research, the Board of Trade and by the Board of Inland Revenue.

The object of the new Association is to establish, in co-operation with the Government Department of Scientific and Industrial Research, a national scheme for the scientific investigation, either by its own officers or by the Universities, Technical Schools and other Institutions, of the problems arising in the Woollen and Worsted Industries and to encourage and improve the technical education of persons who are or may be engaged in the industries.

This necessitates the efficient co-ordination of the existing means of research, and their further development. All British firms who are engaged in any branch of the woollen and worsted industries were invited to join

the Association and thus to become eligible for benefits resulting from the scientific investigations it is carrying out. The scope of the work of the Association includes the investigation of problems arising in all sections of the woollen and worsted industries, that is to say, the growth of wool, scouring, carbonising, carding, combing, spinning, weaving, hosiery manufacture, dyeing, bleaching, printing, finishing and other auxiliary or related processes.

As regards the basis of membership, there was at first a good deal of discussion, and the Provisional Committee spent some months discussing the assessment of subscriptions. It was thought, by a certain section, that assessing subscriptions on a capital basis might be inquisitorial and certain firms who supported the West Riding scheme objected to subscribe on the new scale. These objections, however, were overcome when it was seen that this was the most equitable basis for guaranteeing a constant income.

Subscriptions are fixed proportionate to the capital the member employs in the wool-using industry. In the case of firms whose raw material is only partly wool, the assessment is based on that part of their capital which it is estimated that they employ in the use of wool; and in the case of firms using no wool, but engaged in related industries such as the making of textile machinery, appliances, or accessories, the assessment is such as may be agreed upon between the Association and the contributing firms. All subscriptions are treated as absolutely private and no firm knows what his neighbour's subscription to the Association is, as no list of individual subscriptions is published. The only persons who do know the amounts are the Secretary and the Auditors of the Association. The minimum period of membership is fixed at five years, for clearly, in research, you cannot expect results in a moment; you must give time for them to be developed, particularly in fundamental research. Specific research on individual points may be much quicker, although, here again, patience must be shown, and progress may often in the end be dependent on the more fundamental work.

The management of the Association is vested in the Council, which includes representatives of the industry and of science and technology. It consists of 35 elected members, together with not more than 10 members co-opted from the Honorary members, who must be interested in or connected with the objects of the Association, but who are not liable to it for any pecuniary subscriptions. It has also been agreed with the Department of Scientific and Industrial Research that it shall have the right to appoint five members of the Council.

The Council has power to delegate such of its duties as it considers desirable to Committees on which persons of suitable attainments and experience may be co-opted. At present the following Committees are very active:—

(*a*) Research Control Committee.

(*b*) Education and Improvements Committee.

(*c*) Finance and General Purposes Committee.

(*d*) Joint Committee on Sheep Breeding.

(*e*) Executive Committee.

(*f*) Local Committees throughout the United Kingdom.

In order to obtain the fullest benefit of the technical knowledge of the members for special purposes, it was decided to set up as occasion demanded special Advisory Research Sub-Committees to deal with all questions of research into problems relating to the various processes in the industry, such Sub-Committees to have the power to co-opt any member of the Association who is willing to act and whose special knowledge is considered valuable to the deliberations of the Committees.

The Annual Report and the accounts of the past year's transactions are presented to the Association for discussion at the Annual General Meeting, at which the estimates and levy made by the Council for the ensuing year or period of years are also discussed and confirmed. The election of members of Council and of Auditors, together with any other business of which proper notice has been given to the Secretary, also takes place at the Annual General Meeting.

The Department of Scientific and Industrial Research grants an annual subsidy in aid of research on certain conditions. The Research Association will, like other Research Associations, keep in close touch with the Department, from whom it may expect to receive such information relating to the results of research obtained by similar Associations in other industries as is likely to be of interest to the woollen

and worsted industries. Similarly, the Association keeps in touch with the Government Departments controlling education in different parts of the United Kingdom, and with local education authorities, in order that it may obtain advice and other assistance in carrying out the educational side of its work.

Our Articles of Association also give us power to translate, abstract, compile, collect and publish information of use to the industry from all countries in the world. We have established a Bureau of Information so that anyone coming to Leeds can call in or make enquiries for information. The necessary abstracting and indexing, and the library have made good progress both for the above object and for the use of the Staff.

We are earnestly desirous of improving existing methods and doing everything we can to avoid waste. We want to discover new materials and processes and also discover new methods of finishing so that we can put a better face on to fabrics than we are doing at present. The difference between the finished article in France and that in England is very pronounced. The chief need is unity to give scope for higher aims in the textile trade, to remove trade jealousies, to stimulate and cheapen production on the best technical lines, and to encourage patience and continuity of purpose in research work. Our industry must not be looked down upon as sordid and money-grabbing. We must endeavour to bring it to a higher level than ever it has been before and to ensure that all engaged in it have a better knowledge and a more active interest in it.

During last year the membership of the Association increased to 456, and these firms have agreed to subscribe the sum of £6,879, being an increase of £715 5s. on the previous year. This entitles us to a Grant from the Department of Scientific and Industrial Research of £5,939 10s. Our income for last year amounted to £13,356 9s. 11d., being an increase of £1,174 7s. 6d. over the corresponding period of the previous year. Our financial position, due in part to unavoidable delays in securing permanent headquarters, has enabled us to purchase and equip research laboratories without a special appeal such as had to be made by the British Cotton Industry Research Association.

The Council has agreed to the principle of putting the members of the Staff on the same footing with regard to superannuation as the Staffs of Universities and similar institutions. The details of the scheme have not yet been fully settled, but the question is being dealt with, as it is considered likely to be an attraction to the kind of man most suitable for senior staff positions under the Association.

RESEARCH ESTABLISHMENT.

We have now purchased our permanent establishment, which, during the past six months, has been undergoing the process of alteration into Laboratories and Experimental Workshops. In deciding to purchase a "mansion" with grounds available for future extension, the example of the Association has been followed by other similar bodies, which are working on lines such as those which our Council has already approved, *e.g.*, The British Cotton Industry Research Association has bought for £10,000 a large house in Didsbury with 13½ acres of ground and its first building programme will cost upwards of £80,000, although a building fund of £250,000 is being appealed for. The Linen Industry Research Association has purchased a large property on the outskirts of Belfast.

After exhaustive enquiries and numerous inspections of possible properties, it was decided that in the opinion of the Committee, Torridon, Headingley, Leeds, was the most suitable for conversion into Research Laboratories and Workshops. This estate was purchased for the sum of £5,400, with vacant possession on 4th August, 1920.

Torridon is a freehold property of 3¾ acres and the house contains lofty and well-lighted rooms which are fitted with electricity and heated throughout. Much of the heavy work is completed, but minor alterations and fittings will continue for some time. Up to the present the following rooms have been equipped:—

A large Chemical Laboratory (44 x 20 ft).
Smaller Chemical Laboratory.
Physics Laboratory (39 x 25 ft.).
Various Store Rooms connected with these Laboratories.
Room containing the accumulators, etc., for direct current supply, switchboard, meters, etc., etc.
General and Private Offices.
Council and Committee Room.

Library and Reading Room.
Cloth Examining and Draughtsman's Room.
Photomicrographic Room.
Dark Room.
Caretaker's Flat.

There are also five good sized attics which are at present only being used for storage.

In the Basement an internal chamber has been made, the atmosphere of which is to be regulated from an adjoining apartment both as regards temperature and humidity.

The outbuildings have been fitted with Experimental Milling, Scouring, Hydro Extracting Machines and a simple Tenter. These machines are of such a size as to deal with small but quite practical narrow width patterns. An engineer's shop leading from the Physics Laboratory has been equipped with a lathe, drilling machine, shaper, grinder, etc., to do the small jobs which continually crop up in connection with the Laboratories, and also to investigate possible mechanical improvements.

EDUCATION.

A Grant was made by our Council of a sum of £500 to the Manchester University Colloid Fund, as it was considered that the study of and research in Colloids was of both direct and indirect benefit in the application of Science to the Textile Industries. The Council also decided to make a grant from year to year of a sum of £300 to the Textile Institute towards the cost of the abstracts section of its Journal. These abstracts are very useful to the Research Staff and it is hoped and believed that their usefulness will increase as this Department of the Textile Institute is developed.

The principle of awarding prizes for the best paper in any year on a subject of value to the Wool Textile Industry written by a person or persons not on the Staff of the Association has been considered and approved, although it was agreed that a prize should not be awarded except for a paper considered to be of sufficient merit by the Council. The details have yet to be settled.

The Education Committee has drafted and circulated a complete series of new Syllabuses for Wool Textile Courses, embodying certain recommendations for part time work in the Technical Schools, and part time in the Factories, bringing out the utility of single lectures to men in industry after their normal education at the Technical Schools has ceased, and suggesting that the three years' course in Textiles should be sub-divided into two years' general ground work and one year's specialisation.

With the Report of the Committee which was issued broadly to various educational authorities, was a Foreword urging the needs of Science in a scheme of education and the necessity for teaching Science prior to leaving the Secondary Schools at the age of 18, so that it would not be necessary for youths commencing Textile Courses at this age to have to begin also the study of the Sciences at the same time, but that the necessary foundation in Science should have previously been laid. A recommendation was forwarded to local authorities which were framing schemes for revised courses in Secondary Schools to provide every opportunity for a thorough ground work and training in theoretical and applied Science.

The revised Syllabuses above referred to were submitted to the City and Guilds of London Institute, and it is confidently believed that the Institute will adopt them very shortly. The Association has secured representation on the Education Committee of the National Wool (and Allied) Industrial Council, and is working in conjunction with that body.

The next task of the Committee is to survey the various schemes of Scholarships under different educational authorities, expecially with regard to technical work. It has also been suggested that representatives of the Association be chosen to visit regularly the Technical Schools in the Textile Centres and present Reports along with constructive criticisms.

The Committee has in hand enquiries as to the best possible means of compiling Text Books and references to cover the revised Syllabuses they have recommended. It was considered that a useful purpose would be served by a survey of existing Text Books and the compilation therefrom of a reference Index. Monographs on selected subjects are also to be encouraged. These matters are all being advanced by the index and library system which is being built up for research purposes. We also have power to maintain and endow scholarships for the instruction and support of research students.

SHEEP BREEDING.

With regard to investigations on the production of wool, a joint Committee with other bodies has been formed to organise experiments on the breeding of sheep in various parts of these Islands. In this connection close relations are being established between the members of the Association who use wool and the sheep breeders who are engaged in the production of wool. The ground taken was that although ample supplies of high quality wool have been available hitherto from abroad, yet a supply of better wool at home would be an advantage. The increasing world demand for textile fibres as a whole in the face of stationary or decreasing supplies, also gives an incentive to both growers and manufacturers.

From the national point of view, too, the production and export of coarse low-priced carpet wools seems undesirable, when there is no doubt that much better wools than some at present grown can be produced and used at home or exported as finished goods. Accordingly, at the instance of our Research Association and with the co-operation of the Department of Scientific and Industrial Research, a Conference was held in London on the 21st November, 1919. At this Conference representatives were present from the Ministry of Agriculture and Fisheries, English Breeders of Short-Woolled Sheep, English Breeders of Long-Woolled Sheep, Breeders of Welsh and Scotch Sheep, the Board of Agriculture for Scotland, the Department of Scientific and Industrial Research, and the Research Association.

In the course of the proceedings it was strongly emphasised that an improvement generally in wool without loss of mutton character was desirable. In particular, grey hair, coarse hair and kemps spoil many British wools. Even the smallest proportion of scattered grey or coloured hairs ruin a wool for the bulk of the finer trade. It was agreed that steps shoud be taken to establish some simple organisation to deal with the matter. A small Joint Provisional Committee was therefore elected with the idea of bringing together breeders, men of science and manufacturers. This Committee consisted of representatives of the Boards of Agriculture of England and Scotland, representatives from English, Scotch and Welsh Sheep Breeders, the Highland and Agricultural Society, the Royal Agricultural Society, and the British Research Association for the Woollen and Worsted Industries.

As regards finance, it was pointed out that the Research Association with its many interests and activities should only bear a share of the burden and that other help should be obtained.

During the last year an appeal and summary of the work in hand and proposed was issued to interested bodies and persons, such as Sheep Breeding Societies and individual breeders. It is only necessary to report here that the work is being continued and that there are increasing signs of interest and support in many quarters in the matter of the improvement of British wools. As instances may be mentioned the following:—

The Board of Agriculture for Scotland have arranged to provide Southdown rams and to bear a part of the loss, if any, of breeders who are willing to undertake experiments with a Southdown-Blackface cross. This action was decided on after a conference between the Board of Agriculture, the Sheep Breeding Committee and the Blackface Sheep Breeders' Association at Perth on the 8th September, 1920. At this conference addresses were given by Mr. H. B. Booth, Professor A. F. Barker, and Professor J. Cossar Ewart, all representing the Research Association, and a prolonged discussion followed with the above result.

The Ministry of Agriculture and Fisheries, England, have indicated their willingness to co-operate, and at an informal conference on the 1st December, 1920, agreed to give careful consideration to any proposals the Committee might advance. This business has still to be completed.

The Ministry have introduced a new principle this year, namely, they have as a tentative experiment subsidised three Ram Societies in Wales. Sheep breeding has not hitherto received Government support and subsidy in the manner that have horse breeding, cattle breeding, pig breeding, etc., and the new departure, if it develops (as we may well hope), may be expected to place this country in a still stronger position as the source of so many of the most important breeds all over the world.

Professor J. Cossar Ewart, working also in conjunction with the Department of Zoology of the University of Edinburgh

and with the Board of Agriculture for Scotland, is continuing a number of the experiments. The Department of Agriculture of the University College of North Wales, under Professor R. G. White, is actively continuing and extending work on the pure Welsh and Southdown-Welsh cross.

The Yorkshire Council for Agricultural Education through Major Dent has indicated its willingness to co-operate, and arrangements are under discussion.

Numerous individuals have either initiated experiments or rendered assistance and advice in other ways. Several of the Flock Book Societies have been keenly interested and are evidently keeping the improvement of wool more prominently before them than in the past.

To sum up the situation as it now stands, the result of the Committee's endeavours is

(*a*) That a greatly widened interest in the quality of wool has been created among breeders.

(*b*) That definite steps have been taken in a number of instances; and

(*c*) That the publicity given to the subject has created an atmosphere in which it is hoped the Committee will be able greatly to extend its work.

Woollen Carding and Spinning.

It is safe to assert that not 1 % of the factories in the Woollen and Worsted Industries have a chemical laboratory, and yet such firms are using every day large quantities of oil, soap, alkalies and dyes purchased by buyers who have no scientific training other than a rough practical knowledge. Very few firms indeed keep careful records of their power plant, *i.e.*, the number of gallons of water evaporated into steam and the amount of coal consumed and horse power indicated. The result is a deplorable waste of fuel and efficiency.

In our own works we found that the use of an inferior lubricating oil increased the load by 20 %. This lack of scientific precision and knowledge means an enormous national waste. On the other hand the knowledge and judgment of raw materials, that is of wool and its by-products, is considerable, but here again the lack of chemical and scientific training often leads to mistakes in buying materials with latent defects which are not discovered until the process of spinning is commenced.

The fact is that the whole industry is more or less run by practical training and natural judgment, rather than by the highly scientific training which obtains in engineering and metallurgy.

We have power to establish, maintain and equip experimental factories. In this connection, a deputation met the Huddersfield Woollen Manufacturers' and Spinners' Association, about the middle of 1917 to consider with them the desirability of putting down an up-to-date plant, for Woollen Carding and Spinning on a commercial scale in Huddersfield. Huddersfield had about 1,400 sets of woollen machinery, and they were trying to teach woollen spinning on the black-board at the Technical College. The Huddersfield Woollen Manufacturers' Association came to the conclusion that rule-of-thumb prevailed more in the woollen spinning industry than in any other branch of textiles. We decided that we must tackle that part of the business, and we have come to an arrangement with the gentlemen appointed by the Huddersfield manufacturers to set up carding and spinning machinery to promote this object. Any member of the Association, when this plant is established, can send his own particular blend and have it carded and spun on scientific lines, because we shall have the very best machinery that we can buy, and also a scientific man to see that everything will be well done on up to date lines for the benefit of our subscribers. Probably, other branches will require dealing with in the same way and it may mean, eventually, the founding of a factory on a commercial basis where machinery may be scrapped to make way for improved devices, and where everything can be done to educate and train students in the scope and work of the industry. We want to get into the industry the highest type of brains. We want not only the practical man but to educate the practical man to the highest point of attainment.

The work of the Woollen Carding and Spinning Committee has been in abeyance during the last few months as it was considered inopportune to go on with the scheme during the present slump. Some progress has, however, been made in so far as the Association has purchased a site which was considered suitable by the Carding Research Committee, both as regards size and locality for the scheme under consideration. The site is situated

about two miles from Huddersfield, just beyond the Waterloo Tram Terminus, and has an area of about 2¾ acres. The scheme finally decided upon was to issue formally as small an amount as possible of Ordinary Shares to be held in trust for the Research Association, the remainder of the Capital to be found by the issue of £40,000 6% Debentures. Any profits of the Company are to be devoted first to paying off the interest and principal of the Debentures and subsequently to revert to the Association. Our Council has decided to make a Grant year by year up to £1,000 in return for the large scale research facilities which the Carding Scheme will present. It is, of course, intended to lay the whole proposals before the woollen trade in detail as soon as the financial corner is turned.

CONSULTING WORK.

Besides the scheme of co-operative research for the common good of members of the Association, it is proposed to make provision for carrying on investigations at the request of individual members, at their own cost and for their own benefit. In such cases the work will be done under the supervision and control of the Director of Research and fees will be charged to cover the cost of the investigation.

A good deal of consulting work has been done and members have given evidence of the usefulness of this department of the Association. On the other hand the department is also of direct benefit to research by keeping the Association posted with current trade difficulties, and often by throwing sidelight on some problem which is at first sight not connected with the difficulty presented.

The investigations on periodic faults in cloth and also on suitable oils for wool have both been helped in this way. Consulting work is carried out for individual firms at the actual estimated cost to the Association. But if the results are of a more general value, the charge, or part of it, is waived.

RESEARCH ACTIVITIES.

The organisation of the research work undertaken by the Association is entrusted to the Director of Research and results are published as they are obtained in the form of confidential reports to members after careful consideration by the Research Control Committee. In connection with these publications, any district in the country which wants amplification of the reports which have already been issued embodying the results obtained may request that the particular investigators, who have conducted the work, shall be at liberty to go into those particular districts and give lectures and other explanations under the auspices of the Local Committees of the Association.

Before the end of each year the Council submits to the members a report of the research work already done, together with a programme of the researches which it is proposed to undertake during the ensuing year, and an account of the expenditure incurred.

One of the first duties of the Council of the Association was to make a survey of the field of research which is likely to be beneficial to the industry. The original West Riding Textile Research Committee had already devoted some attention to this matter, and in preparing the full scheme it has been the business of the Association to take account of the work that this Committee had already done. Members of the Association have been asked to assist in the framing of a thoroughly comprehensive scheme by making suggestions relating to that part of the industry with which they are intimately acquainted.

Arrangements are made that any member who considers that the carrying out of any research which is proposed is likely to conflict with the interests of his business may bring the matter before the notice of the Council, and in the event of their deciding to continue the investigation he will have the right to appeal to the Research Department.

As far as practicable, all members will have equal rights to the results of researches, but provision will be made to prevent, where necessary, the business of members suffering through the disclosure of results either to non-members or to members not already engaged in that branch of the industry to which the discovery applies.

We have power in the Articles of Association to enter into arrangements with any manufacturer, notwithstanding the fact that he is a member of the Association, to carry out, and pay for, experiments in his works on a practical business scale.

The Staff at present consists of:—

Director of Research: H. J. W. Bliss, M.A., F.I.C.

Secretary: Arnold Frobisher, B.Sc., F.S.S.

Physics and Colloid Departments: S. A. Shorter, D.Sc.

Chemistry Department: H. R. Hirst, B.Sc., F.I.C. (Milling, Finishing, etc.), and A. T. King, B.Sc., F.I.C.

Engineering Department: A. W. Stevenson, B.Sc., Wh. Ex.

Biology Department: No appointment at present.

Librarian, Assistants and Clerks.

The Research Committee has approved the principle of frequent semi-formal Staff Meetings, for discussion of work and progress, etc., and has reserved the right to attend at them.

The Association has arranged with the British Cotton Industry Research Association to exchange its confidential publications for those of that body. Our own publications up to date have been as follows:—

No. 1. The Electrification of Fibres.

No. 2. Investigations on the Effect of Manufacturing Processes on Textile Fibres.

No. 3. Action of Acids, Alkalies, and Soaps on Wool.

No. 4. Investigations on the Milling of Wool.

No. 5a. Investigation of the Influence of the Various Methods of Manufacturing Worsted Yarns on Single and Two-fold Twist Warp Cloths:

(*a*) Clear Finished.

(*b*) Milled Finished.

No. 5b. Comparison of the Cloth Qualities of Continental and Noble Combed Materials.

No. 6. Notes on Condition in Wool, Tops and Yarn.

No. 7. Periodic Faults in Yarn. Their effect in a Cloth with special reference to Yarns wound on cheeses and spools.

No. 8. Note on Scratch Fluted Rollers, Roller Pressure and Life of Leathers for Noble Combs and Gill Boxes.

No. 9. Some Theoretical and Practical Observations on Milling.

No. 10. Scouring: A Critical Review.

Patents have been taken out on behalf of the Association as follows:—

No. 136074, by William Harrison. Thermometer for measuring the temperature of wool and other fibres while under treatment in the Combing Machine.

No. 35245/20 (Provisional) with Dr. S. A. Shorter, improvements relating to the treatment of wool and other animal fibres for bettering their drawing and spinning qualities.

Our policy in connection with such patents has to be very carefully considered. Patents abroad are in some cases very difficult to enforce, and the choice lies between giving members the start by secret information with the knowledge that it must leak out in a year or two, and publishing to the whole world with the expense of patents and the difficulty of enforcing them when obtained. Each individual case will probably call for special consideration by the Committees.

We may now turn to a brief review of the researches completed, or in hand or proposed.

As already detailed, the first work for the West Riding Committee and for the Association was carried on at Leeds University and at Bradford Technical College.

Almost every one of the Publications is to a certain degree incomplete, being either an interim report or suggesting a further line of work. For instance, the experiments on electrification have led to some results in treating the material before spinning. These results may be of far reaching importance, and are being tried on a manufacturing scale. Several large scale experiments have been made and further tests are in progress. All this takes much time, but it is considered necessary to be very sure of the results by thorough tests before any statement is issued. Or again, publication No. 9. A whole series of experiments on Milling are in view, some of which have been completed; others are in progress, and others in contemplation.

At the present time the work of the departments already referred to is distributed somewhat as follows, though one department naturally works in with another to a large extent and all the matters in hand are not mentioned.

PHYSICS. — The electrification and spinning tests already referred to.

The physical properties of the fibre.

The effect of the moisture contained in the fibre on its properties. This moisture, known in the trade as "condition," varies with atmospheric humidity and has a profound effect on the fibre.

PHYSICS AND CHEMISTRY. — Scouring, both from the colloid standpoint and the practical.

CHEMISTRY. — Milling, theoretical and practical and starting with the effect on the fibre itself of the reagents commonly used and of other possibly new reagents.

The chemistry of the fibre. An immense subject, ranging from the actual constitution of the fibre substance to its reactions with dyes, mordaunts, sizes, loading materials, acids, alkalies, soaps, etc., etc.

ENGINEERING.—It is intended that each of the machines used in the trade should be reviewed, its defects ascertained, possible improvements tried, and the whole published in a convenient summary.

The first three machines to be tackled will be driers (of wool, tops and cloth), oiling machines (for woollen) and the loom.

It will be seen that the field to be covered is immense and it should be emphasised that no one science can make a complete research by itself. For example, if the action of a reagent on wool is to be studied, it is not only necessary to determine the chemical effect, which may be very complicated in itself, but also physical matters such as the effect on strength and on the structure of the fibre and colloid matters such as its swelling. Add such at present undefined properties as handle and spinning power, and it will be seen how much time can be occupied with even a single reaction.

In conclusion, it should be noted that the early work of the Association is bound to be very largely devoted to what is known as fundamental research. The elementary properties of the fibre have in many cases still to be determined, and until such is the case more advanced work is constantly held up.

CONCLUSION.

By means of its various activities as an Association for Textile Research, a Bureau of Textile Information and a Centre for the furtherance of Textile Education, it is hoped that the British Research Association for the Woollen and Worsted Industries will exercise a far-reaching and beneficial influence on the further welfare of these ancient and important industries. In particular we hope that, be the new results of research what they may, the interest aroused will bring employer and employed together in an ever keener mutual understanding of and interest in the processes they control. Such a consummation will of itself lead to greater efficiency and greater strength in these very important industries.

DISCUSSION.

THE CHAIRMAN (Sir Thomas Middleton, K.B.E., C.B.), in opening the discussion, said the paper contained suggestions for a working model of what a Research Association ought to be. The author had indicated how to set about promoting such an Association and how to finance it. Personally, he thought the author's remarks on the best methods of levying subscriptions were very sound. In starting Associations the problem of finance was perhaps the one that required the greatest amount of attention, and it had evidently been well discussed and well settled by the founders of the Research Association for the Woollen and Worsted Industries. The author had described the aims of the industry in a number of very suggestive paragraphs, as, for instance, when he said: "We must endeavour to bring it to a higher level than ever it has been before and to ensure that all engaged in it have a better knowledge and a more active interest in it." In the further sections of the paper the author had set out the subjects with which the Association was now dealing or proposed to deal, and had drawn particular attention to the work which it had done among sheep breeders. That provided a suggestion as to how to promote interest in the work of the Association. Another suggestion which struck him personally as a very practical and useful one was the suggestion for the giving of prizes for essays, a method likely to be of great value in promoting the study of the subject. Turning to the question in which he himself was most interested, namely, the work proposed in connection with the improvement of wool, the improvement of sheep, this was a particularly complex subject. In that connection the position of the country at the present time was very different from its position in the days of Elizabeth, when the wool was of more importance than the sheep, and, while the British farmer was anxious now to effect whatever improvements were possible in the character of the wool, he watched anxiously to see what effect any modifications made might have upon the animal itself, because his interest was in the sale of the mutton to a much greater extent than it was in the sale of the wool. In the previous year all sheep breeders and sheep sellers had found the fleece a particularly profitable item, but in the present year the position was very different indeed. The farmer's attitude, as was indicated in the paper, was one of sympathy and anticipation, and he was willing to co-operate. Arrangements had already been made in Scotland for carrying out ex-

periments in the hope of improving the wool of mountain sheep. When one went more into detail in connection with the subject of the improvement of wool difficult technical questions were found to be involved. In the first place, it was doubtful whether at the present time a satisfactory answer could be given to the question of what constituted a good wool. Some time before the War two of the Development Grant Scholars set out to study the characteristics of wool. They had the assistance of Prof. Barker and of a skilled Bradford wool sortér, and they had skilled agricultural aid. They made 70,000 measurements of wools, but the problem of what constituted a good wool proved to be most complex and an answer to it had not been found. One of the two young men engaged in the research, Mr. P. G. Bailey, a most promising worker in the subject of genetics, was, unfortunately, killed in the War, and the other was not at the present time available for the study of wool. From the point of view of the scientific agriculturist, the immediate outlook for securing workers was not a good one. Such workers required to have a long training and high attainments, and he wished to emphasise this point, because he thought there had been a disposition to underrate the difficulties that had to be faced when attempting to answer the question of what a good wool was and what sheep breeders were required to produce. Then there was another and a quite different question. Looking at the subject from the point of view of the shepherd and the sheep farmer, it might be asked what made wool good? It was, of course, well known that wool varied according to the breed of sheep, but every shepherd and sheep farmer was aware of the fact that different methods of feeding and treatment of the sheep produced differences in the wool. That subject had been exercising the minds of observant shepherds for at least a century and a half, and one of the best treatises that he knew on the subject was written by a shepherd a hundred years ago. That man, who was extremely observant, had noted the characteristics of the wools of the same breed of sheep in many different parts of the country, and his conclusion was: Dry soil, dry climate, and short food—fine fleece; damp climate and coarse herbage—coarse fleece. He believed that the last time the Society of Arts had had the subject of wool dealt with at one of its meetings was in the year 1827, when the Society received a very interesting communication from Mr. C. C. Weston, M.P., of Felix Hall, Kelvedon, Essex, on the subject of the improvement of English wool by crossing with the merino. Mr. Weston sent some magnificent fleeces for inspection, and the Society was so impressed that it awarded him a Gold Medal. His object in sending the fleeces, in his own words, was as follows: "My object is to draw the attention of land owners and manufacturers to an enquiry into the practicability of producing a most valuable and novel raw material of manufacture and to give them such evidence of probable success as shall warrant them giving the subject some portion of their time and thought." Personally, he did not know how much time and thought the Society had given to the subject since 1827, but he had no doubt that after the paper read on the present occasion a great deal of time and thought would be given to the subject in the near future.

THE HON. JOHN MCEWAN HUNTER (Agent-General for Queensland) said he had read an advance copy of the paper with very considerable interest. He hoped the suggestion made by Mr. Weston, the gentleman who communicated with the Society on the improvement of wool, might have some effect in the future and that closer attention would be given to that important question, which had received a very great deal of consideration in Australia. He thought the conclusion arrived at by the old shepherd a century ago, which the Chairman had quoted, was very nearly correct, and that the reason why Queensland produced the best wool in Australia was because it had a dry climate and the kind of food the shepherd had noted as producing the best wools. Very many years ago Australia had started the crossing of their Spanish merinos with Lincolns and Leicesters, as suggested by the writer of the communication to the Society of Arts in 1827. For the last fifty years the big wool growers of Queensland had been closely studying the question of how to produce bigger and heavier fleeces of longer staples and finer textures. They selected from among their flocks the choicest sheep they could find and crossed and re-crossed them, and he thought they had succeeded in producing a very fine class of wool which was as near perfection as possible. The stud stock had been most carefully selected and large sums of money had been paid for the best blood obtainable. Neither time nor money had been considered when it was a question of how to obtain the best possible results in the way of wool. Before refrigeration was established Australia was in just the opposite position from that in which this country was at the present time, the wool being then the only part of the sheep worth troubling about. The population of Australia was small and the carcase was worth nothing, because there was then no way of shipping it and all that could be done with it was to boil it down and sell the tallow thus obtained. That was probably the reason why Australia gave so much attention to obtaining the very best fleece possible. In the previous year Queensland had secured the best price for the year at the London Wool Sales for fine combing wool; it had a larger area of sheep land than any of the other States of the Commonwealth, and owing

to the warmth of its climate much finer wools could be grown than in colder countries. The result of the attention that had been given to the subject was that in Australia the fleece at the present time was very much heavier than it had been in the past; it was now more than double the weight that it was fifty years ago. He could remember the time, when he was a boy, when sheep breeders considered they were doing very well if they obtained a fleece of from 4 lbs. to 5 lbs., and were well satisfied if they got 5¾d. or 6d. a lb. for the wool, but those days had now gone by and a wool grower would not think it worth his while feeding his sheep if he could not produce a better fleece than that and obtain a higher price for it. He hoped to be successful in persuading some of the sheep breeders' Associations in Queensland to link themselves up with such Associations in this country. He had written to the Queensland Government, suggesting that that should be done, because he thought that, though much had been done in Australia to produce a better class of wool, the wool could still be very considerably improved, and an old country like England, where, probably quite unconsciously, sheep breeders had been improving their stock by careful selection, would, he was sure, be able to help Australia very considerably. On the other hand, the care and attention that had been given to the subject by the people of Australia would no doubt be useful to the people of this country.

Mr. P. M. Evans, LL.D. (Clerk to the Clothworkers' Company), said it had given him great pleasure to listen to the paper, and he had been much interested to hear of the progress which was being made in research work in connection with the woollen and worsted industries of this country. He thought such progress reflected a good deal of credit on those who, in the early days of technical education, controlled the policy of the Clothworkers' Company. Over forty years ago that Company interested itself in the textile trade in Yorkshire and did all it could to promote the improvement of the textile industries. He did not think there was a single Technical Institute in Yorkshire with a textile department that had not at one time or another been helped by the Clothworkers' Company. The Company had all along been very closely associated with Leeds University and had erected, equipped, and given £4,000 a year to maintain the textile, as well as the colour chemistry and dyeing departments there. When these departments were formed, those who were guiding the policy of the Company, with the help of the authorities of the University, took care to see that the laboratories were not limited merely to the educational side of the work but were capable of dealing with research questions in connection with textile industries as a whole. He was sure the author would agree that very valuable work had been done at Leeds University in that direction; in fact, he believed the research as to the electrification of fibres, referred to in the paper as being carried out by Dr. Shorter, was performed at that University. With reference to the Continental process of manufacture, to which the author had referred, some years ago a complete set of machinery for carrying out that process was set up at Leeds University, as it was realised that it was essential that people who were going to be connected with the textile industries in this country should be thoroughly acquainted with the Continental process. He had had the privilege of being present at the meeting at Wakefield, which he thought the University of Leeds had some share in promoting and which was held under the able chairmanship of the author, when resolutions were passed which eventually led up to the formation of the Research Association. The relations of the University with the Association were very cordial and intimate, the University being represented on the Association by its Vice-Chancellor and also by Professor Barker, who was the head of the textile department and was greatly interested in the question of wool production. He hoped the Research Association would support the University in the educational side of the work in the same way as he believed the University was supporting the Association in the research side, which was of course regarded by the University as supplementary to the work carried on there.

Sir Francis Ogilvie, C.B., LL.D., said the discussion had suggested to him one or two broader considerations with which he was better qualified to deal than with the more technical points. The interest which the Association took in education was one of its strongest features. Education, especially technical education, might be compared to afforestation. It was a long time before a full return was obtained; if the work was done properly casual benefits accrued from year to year, but it took a long time to obtain the full benefit of the care and skill that had been bestowed on the subject. He thought the clothworkers, the wool manufacturers, and others in Yorkshire, and the Clothworkers' Company in London were to be congratulated on the success they had achieved in the forty years during which they had been working together. The remarks that had been made that evening showed that the feeling in regard to the improvement of the wool industry in this country was so strong and so definite in Yorkshire that the educational aspects of the work had been kept well in the forefront. There was every reason for that course to be adopted, and, even although the results of educational work, as of research, were slow in coming, they were perfectly certain, and the capital expended on education and research would be well returned

as time went on. In connection with the actual work of the Association, he was glad the author emphasised the attention that had been paid to fundamental research, because, however much chemistry and physics had been studied in the past and however great had been the progress made in the knowledge of the chemical and physical properties of most substances used in commerce, it was a rather singular fact that the chemistry and physics—especially the latter—of the produce of animals and vegetables required for manufacturing purposes had not been sufficiently studied. That remained a branch of fundamental research which had very many developments of the utmost possible technical value. The question of staff was an important one, and the author had shown that his Research Association had assimilated the position of its staff to the position of the staffs in Universities in many material respects, and had therefore made it quite a simple matter for a man to go from a University staff to the staff of a Research Association and *vice versa*. He was inclined to think it would be a very good plan if in a great many of the modern Universities previous experience under a Research Association was regarded as an important qualification for work in a University on an absolutely fundamental science, quite apart from work on an applied science, in which case that would obviously apply. Not only had the author been prominent in the promotion of research work before it became really a national affair, but he had given a very large amount of time and attention and the benefit of an extensive experience in business and manufactures to the development of the work of the Association. Research Associations would be of the greatest possible value to every class and every type of man in this country if their affairs were managed by such men as the author. With reference to the point raised by the Chairman as to the comparative antiquity of the recognition of the value of research in industry and manufactures, he believed a notable example of that was the fact that when, in consideration of becoming a partner with England, Scotland received some financial benefits, the money was devoted to the establishment of a "Board of Manufactures" for the express purpose of improving the manufactures of the country.

Mr. Donald Mackinnon said he attended the meeting as one who was interested in some two million bales of wool which the manufacturers of the world were not able to absorb at the present time, and perhaps to obtain some guidance. He had followed the scheme the author had described with intense interest, because he was one of those who believed—and a great many people in Australia held the same view—that science and technical skill and ordinary production should go hand in hand. About the end of 1913 the State of Victoria was approached by Cambridge University with a proposal of that nature to organise the improvement of wool, but at that time the Government had other matters in hand and did not give very much encouragement to the suggestion. It was very encouraging, however, to find that Universities and Technical Schools and Associations were taking up the subject of endeavouring to develop the wool industry both in its producing and in its manufacturing aspects. The improvement of wool production in Australia and the quality of the wool itself was, he thought, the greatest achievement Australia had given to the world, and it had been very largely carried out by the farmers and others who came out to Australia from Scotland many years ago. When the merino was first sent out to Sydney, as a present from King George III., it produced a very poor fleece of some 3 or 4 lbs., but by a process of selection and careful breeding the present average was about 10 lbs., which was an enormous increase and was entirely due to the practical skill of the sheep breeders, many of whom were Scotsmen. The land in Victoria was now being considerably sub-divided for the settling of ex-Service men, and the question had arisen as to whether small sheep farmers would produce as good a class of wool as the larger farmers. The late Thomas Shaw was of opinion that they would, but many Continental and English buyers were of the contrary opinion. There was no doubt that the large breeders had brought the production of wool to a state of great perfection. The small producers had to be educated. Then the question arose in connection with improving the wool that the sheep farmers would not improve a thing unless it would bring them in more money, and the flesh of the sheep would probably bring them in more money than the fleece would. In Australia a considerable number of Lincolns were bred, and Lincolns were probably the best sheep for crossing if a good wool was the object in view, but when fresh ones were imported from England, it was found that they had not anything like so good a fleece as those in Australia. In Victoria a favourite cross for the production of lambs was for a first cross ewe—*i.e.*, the result of matching a merino ewe with a Lincoln ram—to be mated with a Shropshire, because the Shropshire lambs matured very quickly. If the lambs did not sell and had to be carried on into the next year or perhaps two years, and the farmer had to rely on the wool for his annual income, he found he had a sheep that was not profitable. Therefore, a good many sheep breeders were now using a breed that was commonly used in New Zealand, *i.e.*, the Romney Marsh. The first cross between a first cross ewe and a Romney Marsh ram was a very saleable sheep with a very fair fleece, the wool being longer and heavier than in the other case he had mentioned. The tendency in Victoria was for men to farm

small areas and they had to look to all possible sources of profit. The small farmer had to turn over his land, and if merinos were put on to land that had been tilled they had to be turned on to stubble for some part of the time and their wool became coarse. The experience obtained in this country with small farmers would be of great value to Australia and would be very closely watched by the people there. A great deal of the wool produced wanted carbonising—a good deal of the two million bales to which reference had been made required cleaning—and the Germans were very skilful at that work. In conclusion, he wished to thank the author very much for the interesting paper that had been read. He was sure those interested in the subject in Australia would be very glad to watch the work of the Research Association in this country, to copy its successes and try to avoid its failures.

Mr. W. E. Matthews asked the author whether he thought it was possible for the wool industry to produce an artificial fibre with anything like the success that had attended the production of artificial silk. The success that the production of artificial silk had met with had been simply astounding. He had been brought up in the woollen trade and was engaged in it now, and from his experience he did not think there was any necessity for an artificial fibre in that trade at the present time. With regard to homegrown wools, the growers in this country were mostly small farmers who had to rely on the sale of their fleeces to bring them in money to carry on with, and also the climate certainly affected the wool to a great extent. He did not think sheep farmers had ever been able to produce really fine wools in this country. The wool industry in England was largely dependent on outside sources for its wool, and, although he was aware that there was at the present time more wool in the world than was required, he thought the industry could do with more homegrown wool, and any improvement that could be effected in it would be of great advantage.

Mr. G. K. Menzies said he would like to mention, with reference to the Chairman's remark that the Society of Arts had not dealt with the subject of wool for a hundred years, that in 1913 an excellent paper was read here by Mr. C. E. W. Bean, on "The Wool Industry in the British Dominions," and in December last another was read by Colonel Stordy on wool growing in Peru, which dealt with the improvement of sheep, llamas, vicunas, and other similar animals.

The Chairman, in proposing a hearty vote of thanks to the author for his most interesting paper, said that when he first read the paper the paragraph that struck him most was the following: "The fact is that the whole industry is more or less run by practical training and natural judgment, rather than by the highly scientific training which obtains in engineering and metallurgy." There was possibly in that sentence a suspicion of envy of the product which the metallurgist was able to supply as a raw material to the industries which depended upon steel. Personally he could well understand that envy when he thought of the raw material which farmers supplied to the wool manufacturers of this country. This raw material was of a very heterogeneous character, and he did not wonder that the woollen manufacturer longed for a standardised product. It was, however, a very difficult matter to provide that standardised product in the United Kingdom. He had great sympathy with the author in the attitude the latter adopted towards his own industry, and he felt it was very much the attitude that he himself would adopt with regard to the industry to which he belonged. The author had said that the wool industry depended upon natural judgment, and an excellent example of this natural judgment was furnished by the way in which the Research Association of the woollen and worsted industries had been developed.

The vote of thanks was carried unanimously.

Sir James P. Hinchliffe, in reply, said he was particularly glad that the representatives of two important Colonies were present, as he wanted them to realise that this country was a manufacturing country and that, in spite of all the criticisms levelled against it by other countries, it was making progress and would continue to do so. After all, Great Britain was the finest textile manufacturing country in the world, and was fortunate in the fact that its workers were born into the industry. There was a process of evolution in the production of the worker. Many years ago he had been invited to go to America and establish a woollen factory there, because in Yorkshire the yarns produced were so much better than those produced in America. His reply was that if he did so he would have to contend with certain climatic conditions and he would have a cosmopolitan crowd of workpeople speaking all kinds of different languages, and there was therefore no certainty that if he went to America he could do any better than the Americans were doing. With regard to the wool, he thought the policy that was being pursued in order to protect the Australian grower was wrong to a certain extent. When their wool was put into the London sales there should be no reserve put upon it. It should be sold at the market price of the day. The amount offered could be limited if necessary, but when it was once put on the market no reserve should be placed upon it, because then wool would be withdrawn and taken again into stock and a fundamental basis of value would never be obtained, and that

would hold back the improvement of the industry. If the present policy was changed he was perfectly certain that a stable basis of value would be secured, and an improvement would be brought about and more money realised for the wool than was the case under the present method. In reply to the question as to whether the wool industry could produce an artificial wool fibre as fine as artificial silk, at the moment there was no necessity for that. There was in existence at the present time two or three years' supply of wool, but there was also a practically naked world, and that supply would be very readily absorbed if the exchanges were right and if the purchasing power of the people was greater. Mr. Mackinnon had said that a great deal of the wool required carbonising and that the methods of carbonising employed in England were not as good as those of the Continent. He himself had had wool carbonised on the Continent, but there was one firm in Yorkshire who did it better than any firm in the world; the wool spun better and made a sounder product. He believed that during the War Yorkshire had made a considerable improvement in the carbonising of wool; probably five firms were carbonising where one was doing it before, and he thought this country would be able to hold its own against Continental nations in the carbonising of wool in the future. The difficulty in this country was the small farmer. A farmer had a dozen or a score of sheep and they formed, as it were, a by-product of the farm. The wool became mixed with other wools and had to be sorted by skilled operatives at a great expense, the elimination of which would be a distinct national service. He was very hopeful of the results that would ensue from the combined efforts now being made to improve the breed of the sheep in this country, and he hoped those results would be of use to British Colonies.

The meeting then terminated.

OBITUARY.

GERALD RITCHIE, LATE I.C.S.—Mr. Gerald Ritchie died on May 18th, at his residence in Oakley Street, Chelsea, after a long illness. One of the sons of William Ritchie, Sir Henry Maine's immediate predecessor as Law Member of the Governor-General's Council in India, he was born in 1853, educated at Winchester and at Trinity College, Cambridge, and successfully competed for the Indian Civil Service. He arrived in India in 1875, having been posted to Bengal, where he was successively an Assistant Magistrate and Collector, a Joint Magistrate, a Deputy Commissioner and a Magistrate and Collector. In 1895 he was selected by the then Lieutenant-Governor of Bengal, Sir Charles Elliott for the Chairmanship of the Calcutta Corporation, an important appointment, which is in the hands of the Local Government. Mr. Ritchie retired in 1903, and for some time after his return to England was an assiduous member of the Metropolitan Asylums Board. His recently-published book, "The Ritchies in India," augments Hunter's "Thackerays in India," and shows that of 121 descendants of Thomas Thackeray, a Headmaster of Harrow in the eighteenth century, the majority have been directly or indirectly connected with India. Mr. Ritchie's paternal grandfather was married to a Thackeray, and the wife of his late brother, Richmond, under Secretary of State for India, was the daughter of the famous novelist. Mr. Ritchie was elected a fellow of the Royal Society of Arts in 1919.

NOTES ON BOOKS.

THE INDUSTRIAL AND COMMERCIAL REVOLUTIONS IN GREAT BRITAIN DURING THE NINETEENTH CENTURY. By L. C. A. Knowles. London: Routledge & Sons, 1921.

Whether the term Revolutions is a suitable one to apply to the vast developments during the period named is not, perhaps, worth discussion, or whether there is any justification for using the plural. It is generally taken that Toynbee's "Industrial Revolution" meant the sudden and rapid change effected by the substitution of mechanical for animal power, and the consequent introduction of the factory system. This was established, if not completed, by the beginning of the century and went on developing till the end of it.

The author says, "the nineteenth century begins in 1789." Politically and socially the period may be dated from the French Revolution; industrially it may be dated from Watt's improvement in the steam engine in 1764, or the application of his engine to drive machinery in 1790; commercially in 1788 with Miller's first steam boat or better, in 1813, with the first sea voyage (in British waters) of a steamer; or so on. As a matter of fact precise dates obviously cannot be given; at best they are matters of opinion. The period actually covered by the book is from the latter part of the 18th century to the early part of the 20th from the first application of power (first water then steam) to textile machinery, to the war. This is a definite period enough, and well suited for historical treatment.

After a general Introduction, which forms Part I., Part II. discusses "The Industrial Revolution caused by Machinery," and describes the changes in the textile trades, the growth of the factory system, the development of industrial chemistry, the progress of engineering and coal mining, &c. Part III. is devoted to the "Industrial and Commercial Policy of Great Britain during

the 19th Century." Parts IV. and V. deal with mechanical trasnport and its effect upon commerce by land and sea. Part VI. traces the growth of the Colonies and the development of the Empire from the effects of the increased commerce due to the extended facilities for transport, while Part VII. is devoted to the effects upon agriculture of the development of mechanical transport.

It will thus be seen that the whole subject is very thoroughly and completely treated. It may be added that the manner in which it is treated makes the book a valuable addition to our list of industrial and commercial histories.

POSSIBLE ELECTRICAL DEVELOPMENTS.

Speaking recently before the Associated Engineering Societies of St. Louis, Mr. Louis H. Egan, President of the Union Electric Light & Power Co., described some possible developments of electrical science which, he said, seemed unreal and visionary in bald statement, but which assumed credibility when compared with advances of the immediate past. Among these was the transmission of electric power by wireless which, he said, was not over-fanciful in view of the rapidly increasing radius of wireless telegraphy and telephony and definite progress in the control and direction of these messages.

As another measure of the science's strides, he cited that the Union company power plant at the foot of Ashley Street was built not more than 15 years ago to house at capacity machines capable of producing 12,000 kilowatts of power, but that the same four walls now contain machines which will produce 122,000 kilowatts of power in the same time, the tenfold increase being attributable to a tremendous increase of efficiency accomplished for electrical machines. In this connection, he mentioned also the interesting fact that this power plant now has a daily capacity greater than the present daily production of the Keokuk dam.

As a more immediate possibility, Mr. Egan mentioned the use of pulverized coal for steam generation. He said that plants based upon the use of such fuel already were in operation and had definite records of lowering the heat units necessary to produce a given unit of electricity. The remarkable gain in pulverizing coal seemed to be that coal of low heat units apparently acquired the fuel potency of coals of higher heat units. He declared that this was of importance to St. Louis, inasmuch as the coals nearest the city were coals of low heat units.

Mr. Egan declared that the Union company is planning at this time a step toward the establishment of "super production" here by the erection of a plant of from 240,000 to 300,000 kilowatt capacity or nearly three times the company's present generating capacity.

"Super" production, he explained, is the effort toward the concentration of production of electrical energy for a given area, with as great a radius as several hundred miles, in one plant replacing many. St. Louis possessed three basic essentials for "super" production—water power at Keokuk, the proximity to a large body of water and to coal, and a demand which he said is increasing at a rate to require the Union company to double its capacity every seven years.

In this connection he gave a statement of how the Keokuk dam could best be made to serve the city of St. Louis. The restrictions of maximum development of the power at Keokuk at this time, were the lack of demand for power 24 hours during the day, and the inability of Keokuk at all times to supply normal demand due to the fluctuations of the stage of the river. The first lack resulted in quantities of water passing over the dam during the night instead of through the turbines.

The ultimate utilization of Keokuk power would be through a demand centralized in St. Louis whose minimum would be the entire capacity of Keokuk to produce every hour of the 24. This would increase the Keokuk output about one-third, and would necessitate the establishment of steam generating capacity in St. Louis which could, at the time of low water emergency at the dam, send power to Keokuk.

The demand for an operation of such proportions exists among the coal mines about St. Louis, in the municipalities about it, and in St. Louis industry.

THE PEARL SHELL INDUSTRY OF AUSTRALIA.

The pearl oyster is found on the northern and north-western coasts of the Continent of Australia, on a shore length of some 2,000 miles, and since 1884 pearling has been an important Australian industry, giving employment directly and indirectly to several thousands of persons. The fishing is done generally without diving apparatus by Asiatics.

The pearling grounds are in the States of Western Australia, Queensland, and in the Northern Territory. Western Australia produces the largest quantity of pearl shell and pearls, while Queensland and the Northern Territory incidentally to pearling produce a considerable quantity of bêche de mer and tortoise-shell.

The main centres of the fishing fleets are Broome, Cossack, Onslow, and Shark Bay, in Western Australia, and Thursday Island in the Northern Territory. The fishing boats are small and few in a fleet, the average number of vessels operated by one owner being three. The West Australian Government limits the number of vessels of one owner to 15.

A pearl weighing 171 grains and valued at £3,000 has been discovered in Shark Bay, and one of 32½ grains valued at £1,000 at Thursday Island, but the total production of pearls is small in value compared with that of pearl shell.

In 1912, which attained the highest record of recent years, pearls valued at £106,375 and 2,103 tons of pearl shell valued at £530,298 were produced in the Commonwealth, 1,596 tons of the pearl shell and practically all the pearls being found in Western Australian waters. In 1914, £120,225 worth of pearl shell (1,461 tons) was produced and £97,535 worth of pearls.

During the war the industry was very badly disorganised and is only now recovering, that of Western Australia with the aid of a State Government guaranty of £180 a ton. The latest available official statistics, which are for 1917, are as follows:—

Districts.	Shell.	Pearls.	Bêche de mer.	Tortoise shell.
	£	£	£	£
Western Australia	238,344	38,761		
Queensland ...	21,000	572	39,305	278
Northern Territory	4,951		2,759	100

The price of shell has greatly fluctuated. In 1912 the average per ton was £250, in 1917 it was £120, and in September, 1920, it was £210.

The bulk of the shell has been marketed through auction sales in London.

Shell is not as a general rule assorted in Australia, but is sold f.a.q. (fair average quality). In reporting the above particulars regarding the industry the U.S. Trade Commissioner at Melbourne suggests that firms desiring high-grade shell would save considerable expense by encouraging the sorting of shell locally, thus avoiding the waste involved in purchasing unassorted shell, of which a perceptible part may be undesirable, and doing the sorting at destination after paying freight on the lot.

TANNING MATERIALS IN THE BELGIAN CONGO.

Owing to the increased Belgian demand for tanning materials, which until the present have been largely obtained from France or South America, Belgian specialists have lately been studying the possible application in local industry of similar substances derived from the Belgian Congo. The colony produces an abundance of mangrove bark, which could be exported either raw, as has been the practice in French Guiana, New Caledonia, and especially in Madagascar, or could be used for the preparation of the dry extract in the colony itself. The bark could even be used for tanning purposes in the Congo, where small tanning experiments in the Government laboratory at Zambi have given favourable results. It would also be possible in this connection to produce lime in large quantities from the shells found in the river bed.

According to a report by the U.S. Trade Commissioner at Brussels, there are numerous native trees with barks rich in tannin. Among these is the "Mwena," a species of mangrove abounding on the banks of the Lower Congo and its tributaries, the bark of which contains a minimum of 15 per cent. of tanning matter, the trunk and the roots producing an extract running from 50 to 55 per cent. of tannin. The wood itself, which is hard and undecaying, is a valuable by-product adapted for use in the construction of piling, railway sleepers, and ships. Several varieties of the "Terminalia" give barks which render a dry extract entirely soluble when cold, and containing 62 per cent. of tannin. This extract produces an extremely light and well-tanned leather.

The other varieties of native trees producing tannin extracts may be divided into two classes: those situated in the forests along the river bank, of which the barks may be directly shipped by river and which possess the great advantage of being located near centres of population, where their wood can be employed for construction purposes; and the tan-bark trees of the interior, which may be utilized for the local preparation of extracts, which may be more easily transported. The tan-bark industry is thus one of great potential importance for the Congo.

GENERAL NOTE.

Trade of Port of Nice.—According to the annual report of the Nice Chamber of Commerce, it appears that the trade of this port has not recovered at the rate which was anticipated since the war ended. During 1920, the total number of vessels which entered the port was 980, with a total tonnage of 208,357. Of these 283 were French, and 72 foreign steamers; the remainder were sailing craft of various nationalities. Outward bound, the total number was 968, representing a tonnage of 200,409, which included 282 French and 472 foreign steam vessels. Compared with 1919, this shows an increase of 221 vessels in number and 11,087 less tonnage. The total quantity of goods of every description imported last year was 106,812 tons, and the exports were 61,810 tons, making a total of 168,622 tons, or 7,558 tons less than in 1919. This falling off is due to the smaller supplies of coal. The passenger traffic has fallen off in number from 27,222 in 1919 to 10,868 last year. A falling off in the imports of cereals of 15,246 tons last year is also to be noted.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

MONDAY, MAY 30, at 8 p.m.—SIR KENNETH WELDON GOADBY, K.B.E., Medical Referee for Industrial Poisoning, County of London, "Immunity and Industrial Disease." THE RIGHT HON. J. R. CLYNES, P.C., M.P., in the Chair.

SYNOPSIS.

Industrial Disease may be classified into—A. Primary or intrinsic—due to specific deleterious material handled, such as metallic poisons; B. Secondary or extrinsic—general disease predisposed to by the nature of the occupation, such as tuberculosis. Much is known of cause and prevention of disease processes due to occupation, and very little is known of the essential personal factor of resistance and Immunity to Industrial Disease. Natural Immunity — Acquired Immunity (active and passive). General considerations—Susceptibility, natural, enhanced —Anaphylaxis.

Primary Diseases.—1. Industrial Diseases due to bacterial infections — Evidence — Susceptibility — Immunity. 2. Diseases arising from actual contact with poisonous material — T.N.T., drugs — Susceptibility — Immunity 3. Diseases arising from dust, fumes and vapours: —Lead, As., Hg., Paint, Dope — Susceptibility and Immunity.

General Considerations.

Secondary Diseases.—A. Bacterial Infections —Tuberculosis. B. Arterio-Sclerosis.

Necessity of more knowledge on the predisposition to diseases of occupation—especially the part played by minor diseases lowering natural immunity. Industrial Disease—a factor in Unemployment. How more knowledge might be gained and Unemployment diminished —Trade Unions and Labour Organisations.

INDIAN SECTION.

At 4.30 p.m.

FRIDAY, JUNE 10.—SIR GEORGE SEYMOUR CURTIS, K.C.S.I., Member of the Executive Council, Bombay, 1916-21, "The Development of Bombay."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, MAY 30 .. University of London, University College, Gower Street, W.C., 5.30 p.m. Dr. C. Porter, "Recent Developments in Legislation for the Prevention of Disease." (Lecture I.)

Farmers' Club, at the Surveyor's Institute, 12, Great George Street, S.W., 4 p.m. Mr. C. Wrey, "Agricultural Costings."

Scientific Workers, National Union of, in the Botanical Theatre, University College, W.C., 8 p.m. Prof. L. Bairstow, "The Administration of Scientific Work."

Architectural Association, 34, Bedford Square, W.C., 8 p.m. Mr. G. K. Chesterton, "A Layman's View of Architects and Architecture."

TUESDAY, MAY 31 .. University of London, 8, Hunter Street, W.C., 5 p.m. Mr. J. N. Gardner, "Metabolism of Cholesterol and the Sterols." (Lecture III.)

Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi W.C., 8 p.m. Mr. J. S. Dow, "The Use of Artificial Light as an Aid to Various Games and Sports."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 5 p.m. Annual General Meeting. 6.30 p.m. Dr. F. B. Jewett, "Research Work in the United States."

Royal Institution, Albemarle Street, W., 3 p.m. Sir James Frazer, "Roman Life—Time of Pliny the Younger."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Dr. C. T. Holland, "The Snow and Ice Scenery of Switzerland."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Prof. H. J. Rose, "Celestial and Terrestial Orientation of the Dead."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. African Agriculture and its Development."

WEDNESDAY JUNE 1 .. Wireless Society, at the ROYAL SOCIETY OF ARTS John Street, Adelphi, W.C., 8 p.m.

University of London, South Kensington, S.W., 5.15 p.m. Dr. A. D. Waller and Mr. J. C. Waller, "Experimental Studies in Vegetable Physiology and Vegetable Electricity." (Lecture III.)

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m. 1. Messrs. F. F. Beach, T. E. Needs and Edward Russell, "The Composition of Egg Powder. 2. Mr. N. Evers, "The Colorimetric Method of Determining Hydrogen-ion Concentration: some uses in the Analytical Laboratory." 3. Mr. F. R. Dodd, "The Estimation of Woody Fibre in Cattle Foods."

Oriental Studies, School of, Finsbury Circus, E.C., 12 o'clock. Miss A. Werner, "European Expansion in Africa." (Lecture VI.)

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5 p.m. Prof. E. Kiver, "A Great Poet in Another Art—Beethoven."

Royal Archæological Institute, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Mr. G. Mc N. Rushforth, "The Glass in the East Window of Great Malvern Church and its Relation to the St. William Window in York Minster."

University of London, University College, Gower Street, W.C., 5.15 p.m. Prof. W. L. Bragg, "Crystals." (Lecture I).

THURSDAY, JUNE 2 .. University of London, University College, Gower Street, W.C., 5.15 p.m. Prof. W. L. Bragg, "Crystals." (Lecture II.)

Sociological Society, 65, Belgrave Road, S.W., 8.15 p.m. Prof. Abercrombie, "The Municipal Survey of Sheffield."

Linnean Society, Burlington House, W., 5 p.m. Prof. Garstang, "Biogenetic Law."

Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace Road, S.W., 6 p.m.

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Mr. W. M. McGovern, "The Buddhist Literature of China." (Lecture III.)

Royal Institution, Albemarle Street, W., 3 p.m. Sir Alexander Mackenzie, "Beethoven." (Lecture I.)

British Architects, Royal Institute of, 9, Conduit Street, W., 5 p.m. Mr. H. M. Fletcher, "Building a House."

FRIDAY, JUNE 3 .. University of London, University College, Gower Street, W.C., 5.30 p.m. Dr. C. Porter, "Recent Developments in Legislation for the Prevention of Disease." (Lecture II.) In the Physics Theatre, University College, W.C., 5.15 p.m. Prof. W. L. Bragg, "Crystals" (Lecture III.) At King's College, Strand, W.C., 5 p.m. Prof. H. E. Armstrong, "Enzymes in Relation to Plant Growth." (Lecture I.)

Royal Institution, Albemarle Street, W., 9 p.m. Dr. L. Huxley, "Chronicles of the Cornhill."

Philological Society, University College, W.C., 5.30 p.m. Dr. H. Bradley, "Dictionary Evening."

SATURDAY, JUNE 4 .. Royal Institution, Albemarle Street, W. 3 p.m. Dr. R. S. Rait, "Scotland and France."

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

NEXT WEEK

FRIDAY, JUNE 10th, at 4.30 p.m. (Indian Section).—SIR GEORGE SEYMOUR CURTIS, K.C.S.I., Member of the Executive Council, Bombay, 1916-21, "The Development of Bombay." Mr. W. D. Sheppard, C.I.E., Member, Council of the Secretary of State for India, and formerly Member of the Bombay Government, in the Chair.

TWENTY-SECOND ORDINARY MEETING.

WEDNESDAY, MAY 25th, 1921; SIR ROBERT A. HADFIELD, Bt., D.Sc., D.Met., F.R.S., Vice-President of the Society, in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Dalpatbhai, Jagabhai, Ahmedabad, India.
Hart, Frederick A., San Fernando de Apure, Venezuela.
Hudson, Mrs. Mabel Juliette, Derby.
Huggins, George Frederick, O.B.E., Port of Spain, Trinidad, B.W. Indies.
King, Daniel T., Great Yarmouth.
Morgan, J. T., Cardiff.
Park, James Robert, LL.B., London.
Price, Cyril, New York City, U.S.A.
Thakardas, Purshotamdas, C.I.E., London.

The following candidates were balloted for and duly elected Fellows of the Society:

Grove, Rev. John, M.A., LL.B., Perth, W. Australia.
Hamidulla Khan, Colonel His Highness Nawabzada Iftikharul-Mulk Mohammed, Bahadur, C.S.I., B.A., Bhopal, India.
Matteson, Herman Howard, M.A., B.S., M.D., Washington, U.S.A.
Oakley, Major Robert McK., V.D., Melbourne, Australia.
Pollard, Harold, London.
Seabrook, A. Hugh, M.I.Mech.E., M.I.E.E., London.
Wreford, Arthur T., London.

A paper on "The War and Industrial Peace: An Analysis of Industrial Unrest" was read by DR. C. M. WILSON.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, MAY 4TH, 1921.

THE RIGHT HON. VISCOUNT BRYCE, O.M., G.C.V.O., D.C.L., F.R.S., in the Chair.

THE CHAIRMAN, in introducing Sir Geoffrey Butler, said he felt it a very great pleasure and honour to be asked to preside at the meeting, when a paper was to be read on a subject of far reaching interest not thoroughly understood in this country, a subject which was to be treated by a traveller, thinker, and writer so eminently competent for the purpose as Sir Geoffrey Butler. He had had the privilege of reading an advance copy of the paper, and, without pledging himself to agreement with every point the author had made, he thought the general trend of the paper was singularly judicious, temperate and penetrating. The author seemed to have grasped some of the salient features in which the American character differed from the British, and had compared the characters of the two people with remarkable exactness. One point that had struck him particularly was that the Americans entered upon any work they undertook with a certain kind of enthusiasm less common in England. They also possessed a certain originality and boldness in trying experiments, which the author had happily illustrated by referring to some architectural features of New York. He agreed with the author that the people of this country ought to endeavour to reach a better knowledge of the United States and the American people. They must not imagine the latter to be the same as the British people, though no doubt the two peoples had many and important points of similarity. There were two great mistakes that might be made in that connection. One was to suppose that the Americans were the same as the English and the other was to suppose that the Americans and the English differed as much from one another as either of them differed from most, perhaps indeed from all,

peoples of the European Continent. There was a great likeness between them, but there were also points of unlikeness, and only those who had studied the subject thoroughly, who had lived in America and come to understand the spirit of its people, were able to discriminate and to know exactly in what points the difference existed and in what points the essential underlying features of national character were still efficient factors. The author was quite right in saying that the forces working in and upon both peoples were often similar and the action of the forces was often similar, but the *terrain* was not the same, and that made a great difference which must always be allowed by the historian and by the statesman.

The following paper was then read :—

ANGLO-AMERICAN RELATIONS:

A Personal Impression.

By Sir Geoffrey Butler, K.B.E.,

Fellow and Praelector in Diplomatic history at Corpus Christi College, Cambridge; Director, British Bureau of Information, U.S.A., 1917-19.

Almost exactly four years age the White Star Liner Olympic slipped down the Clyde on a bright spring evening bearing to America a small party of officials. At their head was Mr. Balfour: they were bound for Canada and the United States. Thus the British War Mission in the United States was inaugurated. Into it were gradually gathered all the officials who up to then had carried on the multiple negotiations which had taken place during United States neutrality; while, under the leadership, first of Lord Northcliffe, and afterwards of Lord Reading, it assumed proportions and tackled problems which members of the original party could only dimly have foreseen. How far it performed its functions with success is not for a member of the mission to discuss. Certainly the staff was large and varied. There were diplomats, financiers and members of the Bar, sailors and soldiers, Members of Parliament, labour leaders, doctors, journalists, dons, and civil servants. Almost every corner of the Empire was represented, and one cannot forget the work of some very able women. The sum of experience upon which the chiefs of the Mission could draw was considerable, especially owing to the fact that none, except the disabled, were of military age. There were in the organisation financial and purchasing departments, inspection and intelligence branches, staffs which dealt with shipping and food and petroleum; all these apart from the more specifically military branches of British co-operation with the United States. At a gathering of the whole staff towards the end of the war, I think I am right in saying that some three thousand persons were present. Taking the number of those who came and went, together with those scattered all over the country, it may be guessed that not fewer than five thousand persons from first to last came into close and continuous contact with Americans during those months of the war. Now when all allowance has been made for the many Canadians upon the Mission, and for those from the British Isles who had long been familiar with America and American conditions, it can be affirmed without fear of contradiction, that a migration upon so large a scale, and a transplantation so intensive into American surroundings, of members of the British professional classes was unprecedented. I have not infrequently pondered upon this aspect of the dispatch of the British War Mission to the United States, though I never recollect in the many references to its activities which I have read, seeing it referred to as a sociological phenomenon of an unusual character. Accordingly when asked to address you upon the subject of Anglo-American relations, I ventured to choose the particular rather than the general, and to select it as my theme.

I was sorely tempted to approach this sociological experiment in the scientific spirit. It should be possible to trace the re-action of some of these very different individuals to the American spirit and environment, but although a large number of them passed through my office just after their arrival in the United States, and just before they left it, and although it has been my good fortune to retain contact and friendship with not a few of them, despite the time that has elapsed, he would be a bold man who, in the present position of exact measurement in mass psychology, would presume to summarise in any formula what is the feeling of them all. It was tantalising to point out that the members of the mission have formed an organisation and still celebrate an annual reunion, that many have worked and are still working among their fellow countrymen for a better understanding of American affairs. Above all I should have liked to have seized this opportunity to emphasise

the conviction, which such action upon their part might be interpreted to justify, the conviction that for the future of our country it is far more important that our young men and women should go to America for a brief period of their education, than that American young men and women should come here for a period of theirs, important as this latter is. On reflection, however, I decided to avoid basing generalisations of this character upon the experience of others. I determined to ask you to bear with me while I subjected my own experience to analysis, not because it was important, or even perhaps typical, but rather because I could make it more exact.

Even if by means of this method it is possible to produce in my audience the sensation of a quickened sympathy with some currents of thought and life in the United States, one must be on one's guard against that confusion of thought which, so far as nations are concerned, associates progress in mutual understanding with improvement in international relations. Mr. J. E. C. Bodley in his well-known work on France, goes so far as to point out that since the days of the Crimean War "most of the wars in which Christian nations have contended have been between combatants who had an intimate acquaintance with one another's language, institutions, and social customs:" while he pertinently asserts that the period at which Franco-British relations were most strained was not "when the colonels of the Second Empire—their martial appetites whetted by the Italian campaign—threatened us with invasion" but "under a monarchy modelled on the English pattern," at a time "when the foreign affairs of France were directed by the most enthusiastic and well-informed admirer of English institutions the world ever saw—M. Guizot." There is something to be said on the other side to this very sweeping statement, but however much truth it may or may not contain as a general proposition, there are definite and perhaps exceptional advantages in a growth of knowledge of America among our British peoples, and these, as I hope to indicate, are independent of the considerations which primarily appeal to our respective diplomats.

Now first and foremost among the advantages, which a closer acquaintance with American conditions has to offer its possessor, I put the realisation that Great Britain and the United States are entirely separate countries. A volume could be written on the subject and a large portion of the volume would have to be devoted to qualifying the original premise. Of course there is truth, and inspiring truth, in the fact that American legal institutions and practices are dominated by British thought, that the course of American history can be traced back to the struggles, alike to the victories and the defeats, of the British Monarchy, the Parliament and People. But such considerations are for the technical writer and the specialist. The American politician does not find them a force to reckon with, and indeed seldom invokes them. The forces, which by their interaction beat out progress in these islands, can often be detected at work in the United States. But the terrain, on which they are working, is not the same: consequently the speed and force at which they work is variable from that with which we are familiar. It was for want of appreciating this fact that British liberalism made its ghastly mistake of backing the wrong horse in the Civil War of the sixties; and, if the lesson of that blunder is not digested, there is danger of considerable Anglo-American estrangement when labour is once firmly in the saddle of government in England. Apart altogether from considerations of this nature there is no advantage to be served by pretending the existence of an ethnical, traditional or other tie, which, if they ever did, are now ceasing to exist; there is positive gain in starting from a postulate, which though exaggerated, is far more nearly true. "By distinguishing I arrive at truth," said a famous philosopher. It is more comfortable to lay emphasis upon the likeness of other nations to our own: it may be more complimentary to the other nations to enumerate and discuss the differences which separate them from us. It is conceivable that in some respects a nation may be found to excel our own as a repository of wisdom.

No one who appreciates what Anglo-American friendship might mean can be happy at the present position of Anglo-American relations. One of the most dispiriting articles upon this subject which I have ever read, was from the pen of one who claimed to be an optimist. It appeared in a well-known Sunday paper. The gist of it lay in the contention that no subject for difference of opinion between the United States and England at the present day

could compare in importance with those that had existed between the countries during the American Civil War. Gracious heavens, how comforting! Read the autobiography known as "The Education of Henry Adams," his gloomy, bad-tempered but fascinating, description of that cat and dog period, provides a useful commentary on any one who would take it as the standard from which to measure the relation of those who for two years, and for almost identical reasons, have fought together the greatest war of history. Now the points, which may conceivably estrange the two nations, are several, but looking away from such matters as the exploitation of the world's oil resources, the regulations governing the Panama Canal or rivalry in the carrying trade of the World, important enough matters in themselves, but all the kind of questions that have in the past proved patient of diplomatic adjustment—there are two directions along which the action of the United States Administration will be carefully watched in this country by every man or woman who reads a newspaper.

The great American Admiral Mahan, writing of the Monro Doctrine, speaks of it as bearing witness to, and as having developed in the United States a "national sensitiveness" as to the entanglement of trans-atlantic Powers in cis-atlantic affairs. The phrase is suggestive in any discussion as to the nature of that doctrine. It is helpful when one is speaking of the British attitude of mind as to any challenge to British naval strength. Rightly, generations of history have fixed firmly in the British consciousness a "national sensitiveness" as to sea power. For them it is vital to be supreme at sea; for other nations it may be desirable, but it is in comparison a luxury. In chance utterances as to naval strength, American pronouncements are, and for some months have been, giving food for much thought over in this land; in fishing hamlet or pit village as much as in the greater centres of population. There is hardly a single section of the community left unaffected by such talk and thought. Add to this the fact that at least one section of the nation sees with little short of horror the virtual withdrawal of the United States from all the responsibilities of those world privileges, which it has in fact assumed and was supposed, wrongly perhaps, to have demanded. That part of President Harding's message which was most cheered by all the men and women present, says the *Times* correspondent at Washington, were the phrases in which he announced that the United States would never enter the League of Nations. Those who know most of America are least astonished by the refusal of the people of the United States to allow their government to participate in the League of Nations. Nor does anyone challenge their perfect right to do so. But in this life political actions are not performed *in vacuo*. You have to pay a certain price for your fun. The crowds who raised the cheers in the galleries of the House of Representatives, probably did not think of, or care for, the effect that the *Times* correspondent's account of those cheers would have upon so-called progressive elements in England. It is not reasonable to suppose that they should, but it is a case of that tragic irony, which haunts Anglo-American relations and a fact that the two governments may have some day to reckon with, that America in Labour and other "progressive" circles is coming to occupy not of course merely in its attitude towards the League of Nations, a position as a force on the side of re-action.

Now currents of this nature unite and thereby a morbid condition of public opinion is produced. There are, of course, alternative methods of handling this, as other manifestations of morbidity—a wrong way and a right way. It is possible for national beings to be hypnotised by symptoms they know to exist and deplore. Deeper and deeper they become involved, and the disease feeding on itself proves fatal. It is important that thinking men and women, friendly to the United States, should not allow themselves to fall victims to the mesmeric influence of those symptoms in the two nations which they wish to cure. I remember a United States Senator from a Western State, who all through his career had been a good friend of our country, told me that in his early and middle life he had wished to see an act passed for providing, at public expense, silencers for the Fourth of July orators, but that, now that he was becoming an old man, he was not at all certain that he would not vote for preliminary legislation to provide the same at the same charges for after-dinner Pilgrim speakers. Now neither the Senator in question, nor anyone else of friendly disposition, is blind to the beneficient activities of the Pilgrim and kindred societies

(their services to Anglo-American friendship are too notorious), but it cannot on the other hand be questioned that the gatherings or the publications of such societies have provided opportunities for pronouncements that anyone conversant with the real state of opinion in the two countries, often no one more than the members themselves of such societies, must regard as highly injudicious. During the war there was something very touching in the manifestation of good-will toward America that was shown by such acts as the flying of the Stars and Stripes over the Houses of Parliament at Westminster. But what was nobly done then, because spontaneously under the inspiration of a great crisis, has been adopted with the best intention in the world, by some people as a model for British behaviour in these days, and in the fond hope that it will have a beneficial effect upon Anglo-American relations. Hence far worse, one still, in articles or speeches written by British enthusiasts, meets with the tacit assumption that the United States is, as it were, a Dominion which "chose the other way," hence comes the talk of "hands across the sea," or "blood being thicker than water." Hence we are advised to re-write our English history of the XVIII. century, and to tell falsehoods with a purpose about George III., or about English public opinion in the time of Burke. No short cuts like this will take us to the desired goal. It is poor diplomacy to make any overtures if they are not going to be accepted, and overtures of this nature indicate, and are taken for, not dignity or strength, but weakness. They may consequently do great mischief before they are openly repudiated by more responsible British opinion.

In other words, in the face of the obstacles to a full and perfect understanding between the two nations, I see no hope either in ignoring the obstacles or in seeking to avoid them by short cuts. I believe that a more normal attitude toward these obstacles is attained by shifting the centre of one's interest to a somewhat different quarter. By treating the United States objectively, by making it the object of disinterested and untendencious study, it may be found possible to set English ideas and institutions, never in such a state of flux as they are in to-day, up against an external standard—a process which, rightly handled, may be made informative. The idea is not a new one. It was the prescription, under utterly different conditions, of Matthew Arnold for the England of his day, though his recommendation to England of the eighties was a Socratic investigation of continental standards. Since the eighties events have so happened that there is now in the United States a store of experience from experiment the very existence of which is at present hardly known in England. I prophesy that for the next hundred years, whatever other changes may come over the higher education of this country, and I am not likely to undervalue our present system, the inclusion of a visit to Canada and the United States will (one recollects the analogy of the Grand Tour) increasingly be regarded as a normal part of the intellectual discipline of our educated classes, and I wish to devote the concluding portions of my address to this suggestion. It may or may not be a novel idea, but I am sure it is a coming idea, that of the intellectual stimulus which lies for the English average man and woman, in early life or later, in a transatlantic visit. Like all educational ideas it will have its day and others will succeed it: but I find in the attitude of mind which will make its development on a general scale possible, a far more healthy outlook towards the United States than any other at present feasible. Let me repeat my warning that all the study of America, on whatever scale and however successfully pursued, is not going necessarily to improve the relations between the countries. These are not patient of rapid improvement; there are pessimists who say that they can never really be improved; and others, with more wisdom, who say that the next steps taken to improve them will not be taken from the British side. Be that as it may, it is everything that in the meantime the English people should adopt a positive, not a merely negative, attitude to the United States. The next fifty years under these conditions might, I believe, see English thought enriched in a great many directions. And is it not conceivable that the same period may witness also changes in the nature and outlook of the two countries, changes not now imaginable, which would rob half the present points of friction of their smart? Who can yet say that anyone living to-day has an accurate measurement of the Pacific problem as it will be presented to the coming generations? It is a comforting thought in this connection that hardly a quarter of a century ago we were upon the verge of war with

France. The vast and dreary waste in which are to be found the matters which divide the English-speaking peoples has not yet been scientifically surveyed. "Here be lyons" was a frequent entry upon old fashioned maps. There are "lyons," emblems of contention, on the maps which Americans and Englishmen to-day are using. Perhaps they too will disappear at the mandate of exacter science.

It is hardly possible for me within the limits of to-day's opportunity to convey to you the individual features which in my judgment make a visit to the United States a source of constant stimulus to the educated Englishman. It is obligatory on me then to compress them within the limits of a general idea. That idea I would call "*a study in the influence of enthusiasm upon tradition.*" For tradition within its limits is immensely powerful in the United States. The last three quarters of a century have seen a cataclysmic change from the unlovely America described by Dickens, the gloomy Victorian America of the red stone, Dutch stoeped houses of New York, the more attractive, but still intensely provincial New England of the Transcendentalists or the Baltimore and Richmond of high hearts and lovely women. There has been the peopling of the West and the coming of the immigrants. There has been the industrialisation of the North, no longer kept from sprawling over that historic, but imaginary, line, across which, with varying fortune, was fought the greatest, and, please God, the last, war between English-speaking combatants. There has grown up the America of the Inter States Commerce Commission and of the Federal Reserve. Yet tradition still holds fast. I do not refer alone to the rigidity of the Constitution, which has sometimes been exaggerated. The spell of tradition is felt in political ideas—*vide* the tenacity of individualism which is not only traceable to the natural proclivities of an expanding country—in social customs—have you read "Main Street," the latest novel of the Middle West?—in almost every form of thought and word and deed. That this is so gives providentially a point of contact with English thought: alone, however, it would not provide it with a stimulus. The arresting feature lies in the fact that while the traditional element is strong in American belief and practice, it is combined with qualities which make the American the most daring of experimenters. It needs no disquisition upon the part played by the interaction of authority and initiative in all extension of knowledge, to indicate that, if my diagnosis is right, America is very well worth watching at the moment. Before I go further, however, let me give a concrete example for discussion.

It was as a matter of fact in considering the architecture of New York that I began to stumble on my theory. I suppose there is no one upon whom it does not leave an uneffaceable impression. It was amusing to see how every foreigner responded to the classic purity of design, the gleaming white marble shewing its razor edge against the blueness of the sky, the refinement. and sureness of the scale, in detail. The diplomat saw the interior of those two vast terminals, which make St. Peter's, seen beneath the dome, look squat; the graduate saw a street, which in its blazing and exciting beauty made the High look sordid. I shall never forget walking down town beneath the sky scrapers with a member of my staff, that ingenious architect, Mr. T. H. Lyon, whose lectures in Cambridge on American architecture have recently provoked no little interest. He showed me the evolution of the sky scraper; how, its builders faced with the necessity of building up by the restricted building space available, the original sky scraper—one may see an example in the so-called flat-iron building—consisted of a number of *horizontal* stories piled one upon another. The external appearance, however, of such a building could never have been anything but monstrous. Any house must present to the onlooker a front of which the base, the roofing and the intermediate space will be arranged in some intelligently agreeable proportion. How was one to order this proportion on the front of a sky scraper of thirty stories? The problem defied solution. Either the base must have been so big as to crush the passer by and the ordinary furniture of an ordinary modern street; or, if made in proportion with these latter, the whole front of the building would have been jumbled out of scale. Tradition had beaten the American; but no, enthusiasm produced the experimenter, and it was an experiment which justified itself. Some architect, by a stroke not short of genius, abandoned the analogy with house-building, choosing to make his analogy a classic column. Here the component sections, capital, shaft,

and base, offered precisely the proportion that was needed. The Biltmore building is a classic column, the lines are *vertical*, not horizontal, the windows giving the effect of fluting. Very exquisite are the capitals of certain of these monster columns; and they exhibit every variation, from what may be termed the simpler Doric style, through the Ionic, to the florescence of the Corinthian.

The comments of my friend appeared to me suggestive and to have a general application. If this architectural achievement proved an isolated phenomenon, then it might have had no more importance than any clever device of a technician in any craft—than, for example, the invention of a new surgical saw or the perfection of the cow catcher. The more I pondered the matter the less content was I to leave it to be classed, like the egg-balancing feat of Christopher Columbus, with the achievements of a lucky cunning. There came to mind the modern short story, the contribution to literature of America's one-world influence in letters, Edgar Alan Poe, and the characteristic development of the short story in America by a succession of writers down to O. Henry and George Ade. There came to mind also reports of the way in which American scientists saw and developed, before the scientists of other countries, those two branches of Science to which we in England have recently woken up to pay so much attention, known as physical chemistry and bio-chemistry. There was too that great school of law, the Harvard Law School, whose revolutionary work in the last quarter of the XIX. century might have remained unnoticed in this country, and without effect upon our study of the law, but for the perspicacity of Sir Frederick Pollock: not to mention the strides made by Americans in Clinical medicine, so great that a prominent London surgeon used to me, half joking, but also half in earnest, the phrase that on the clinical side of the profession we "were in the middle ages" as compared with the United States.

I will not extend the catalogue. I contend that the phenomena observed are widely distributed, and that they have a common feature, that each, I mean, is an instance in which, while working from within a tradition, progress of a startling kind has been produced by boldness in pushing forward, a readiness to scrap and start again, which often seems to outpace logic, and to treat lightly scientific proof. In other words one is watching the action of enthusiasm.

I am not claiming that this quality has given the United States the leading position in letters, law or science. Whether there is any such thing as a "leading position" in this sense is not too easy a question to answer. Anyone who lives in Cambridge at a time when the scientific schools of that University each term make life a little more exciting and romantic: when the dream of the middle ages, the transmutation of metals, has been accomplished not a stone's throw from one's door, anyone I say living in these conditions is not likely to put forward preposterous claims on the part of the United States to a lone pre-eminence; but it is possible to claim that it is something not far removed from a unique position which this enthusiasm gives her. For this enthusiasm is specifically American. It is not the same as imagination or intellectual energy, in which our British writers and scientists so much excel. It works in a more practical plane. It is the informing spirit of action, and without action it ceases to exist. Accordingly it produces much waste action, much failure which seems ludicrous, attempts that seem chimerical from the critical standpoint of pure intellect whose standards are static standards not dynamic. Half the personal friction between an American and Englishman, whenever it is found to exist, can be traced ultimately to the reciprocal misunderstanding of this quality and of its absence. However this may be, it is a quality which has a large part yet to play in the history of the globe; and the turn of the arts and sciences and economics, as this country in this century is settling down to study or to practice them, is towards an atmosphere not unsympathetic to it.

That then is my judgment on the present situation. You may do harm by concentrating too fixedly upon the rain clouds, just as you will do foolishly to leave your raincoat in the house. There is much that can be done whether the day is bright or overcast. Study America. Believe that it is the differences from, not the similarities to, England which have importance. In deploring the evil effect of gush upon the situation I urge everyone of the audience to continue and increase every chance of personal contact and co-operation with American men and women. I advise this

in a frankly selfish spirit. It is then that you will get to know of great intellectual and social forces of which this country knows too little. Do you remember how twenty years ago there was no comic paper which did not make frequent fun of the methods of advertisement in the United States? Compare the British advertisement of twenty years ago with that you find in the British papers of to-day. Consider what was done in the war by advertising: and reflect how advertisement, or publicity, has been caught up into the mechanism of democratic politics, by comparing the long statements from all sides in the newspapers during the crisis which preceded the present Coal Strike with the jejune columns of a paper of the nineties. We learned the lesson from America. We even surpassed our teachers, for their war publicity was closely based on ours. That would make an interesting study in itself, but its significance for us lies in the fact that to the coming development of that phase of Anglo-American relations, which I have to-day commended to your notice, there have been interesting past parallels in other spheres.

"Check gush and cultivate knowledge." Does the advice seem cold and priggish or, worse still, hopeless? Not I think if we can keep the end, which we pursue, still enveloped in romance. I protest to you, Ladies and Gentlemen, that again and again, as I think of America, I find in my thoughts those lines of Andrew Marvell addressed "to His Coy Mistress—"

Had we but world enough, and time,
This coyness, Lady, were no crime.
We would sit down and think which way
To walk and pass our long love's day.
Thou by the Indian Ganges' side
Should rubies find: I by the tide
Of Humber would complain. I would
Love you ten years before the Flood,
And you should, if you please, refuse
Till the conversion of the Jews.
For, Lady, you deserve this state,
Nor would I love at lower rate.
But at my back I always hear
Time's winged chariot hurrying near;
And yonder all before us lie
Deserts of vast eternity.
The grave's a fine and private place,
But none, I think, do there embrace.
Now, therefore, while the youthful hue
Sits on thy skin like morning dew,
And while thy willing soul transpires
At every pore with instant fires,
Let us roll all our strength and all
Our sweetness up into one ball,
And tear our pleasures with rough strife
Thorough the iron gates of life:
Thus, though we cannot make our sun
Stand still, yet we will make him run.

DISCUSSION.

[Owing to LORD BRYCE having to leave the meeting, the Chair was taken during the reading of the paper and for the remainder of the meeting by SIR HENRY BABINGTON-SMITH, G.B.E., C.H., K.C.B.]

THE CHAIRMAN, in opening the discussion, said he was sure he would be interpreting the wishes of all those present in expressing to the author their very great appreciation of the paper which had just been read. It was the paper of an acute observer and a clear thinker, who had had exceptional opportunities of observation in connection with the matter with which he dealt, for not only had he spent a considerable time in America in performing various functions connected with the British War Mission, but he had carried out, with exceptional skill and success, special work as head of the Department which dealt with British publicity in America. In that capacity it was an important part of his functions to reflect continually upon the causes affecting public opinion in the two countries. The author had quite rightly treated the work of the British War Mission as a remarkable sociological phenomenon. Those who took part in it would never forget the experience, which placed them in contact with American life under conditions which resembled those of a forcing house. The stress of the war and the urgency of the work to be done led to an intimacy of contact with the corresponding American portions of the machine which would have taken years to establish in peace time. As Sir Geoffrey had pointed out, an indication of the lasting impression made upon all those who took part in that Mission was the fact that they had joined together in an organisation which was intended not only to keep them in touch with one another, but to help them to use their joint efforts in any way that might be practicable for furthering good relations between this country and America. The author correctly diagnosed the cause of much of the difficulty which arose in Anglo-American relations as a morbid condition of public opinion. There was a habit of mind, existing not on one side of the ocean alone, which tended, whenever any cause of difference or of irritation arose, not to remove or to smooth

down that cause, but rather to magnify it. That habit of mind, like morbid habits of the body, must yield, he thought, not to any violent treatment, nor to any stimulants or drugs, but rather to a certain *régime* consisting in great part of studying the conditions in the other country and of personal contact with it in all possible ways, particularly in the impressionable period of education. That was the author's view, he thought, and it was an eminently wise one. Although it could hardly be expected that that particular method would apply to more than a small proportion of the population of either country, still he was sure the author was right in saying that it was one of the most potent means that could be adopted for amending and ultimately remedying this morbid condition of public opinion. He thought it would be generally agreed also that that condition of public opinion would not be satisfactorily treated by enthusiastic expressions of unity. Confidence was a plant of slow growth, and its growth would certainly not be promoted if it was continually pulled up for its roots to be examined.

The Right Hon. Sir Frederick Pollock, Bt., K.C., D.C.L., said he entirely agreed with the general gist of the paper and only wished to make a few desultory observations. In comparing the people of this nation with those of any other nation, it was unfortunate that there was no very convenient word by which to express our insular characteristics as a whole. All the rest of the world said "English"; even the Americans used that word quite as often as the word "British," and in France the word "*Britannique*" was never used except in strictly official documents. Even "British" was insufficient, because it did not properly include Ireland. Therefore people talked about the contrasts between the English and the French or the English and the Americans, and left out important parts of the United Kingdom which might be particularly useful in that connection. The author had not mentioned the name of Scotland, but he ventured to say that Scots might perhaps be more useful than Englishmen in the matter under discussion. There were certain resemblances between America and Scotland which he wished he could find existing between America and England. In Scotland there was a general high level of education and a general respect for learning even among people who were not themselves learned, and that was also the case in the United States. Again, there was a great deal of enthusiasm in Scotland, as there was in the United States, and he was not at all sure that some of the American enthusiasm which the author had quite rightly praised did not come from Scotland! There was in both countries a combination of strong local patriotism and the capacity for enthusiasm about greater objects. Many years ago he met in Virginia a Virginian from the mountain district—a perfectly good Virginian and American—who had not forgotten that he was a Scotsman; he had not forgotten his Scottish ancestry or even altogether his Scottish customs. That was the sort of spirit which rather tended to die out in England. Again, a Scotsman might be prejudiced and narrow-minded and perverse, but he was very seldom stupid, and personally he had met very few stupid Americans. All that the author had said about the necessity of avoiding gush was absolutely true. It was absurd to talk about differences being unthinkable—nobody talked about differences in a family being unthinkable. When family quarrels did come they were the most troublesome of all quarrels. Not only should the people of America and of this country avoid gush, but they should be perfectly frank with each other, and they should be very careful to avoid the dangerous error of patronising each other. There was a time when European writers thought they could afford to patronise America, and now it was the other way about and certain second-rate American publicists thought they could patronise this country. The peoples of the two countries should steer clear of gush on the one hand and patronising on the other and be perfectly frank with each other. His own experience was that when an American understood that a Briton was talking to him as an equal and did not mean any nonsense, the Briton could afford to be perfectly frank, and that was equally true in connection with Canadians and Australians, who were not so absolutely like Englishmen or Scotsmen as was generally believed. It was very important that the people of this country should go to America and see things for themselves. They should not be downhearted about the difficulties of understanding the Americans; they had to try to understand people within the British Empire who were very much more different from them than the Americans. In the case of America there were about one and a half centuries of divergence from this country, while in the case of India there were not less than three or four thousand years of divergent civilisation pursuing different objects in different ways, with widely different languages and traditions. If this country welcomed India as an active partner in the British Empire and hoped to keep the British Empire together with all its miscellaneous constituents, it might reasonably hope to maintain a good understanding with America. With reference to the remarks the author had made about American architecture, he would like to make one claim for British and even London architecture. There were some architects in London who knew how to use vertical lines, as was shown, for instance, in the Kodak building in Kingsway. He was not prepared to say the the architect of that building did not learn

the idea from American architects—if he did, so much the better. It was quite true that modern American architects had a great deal to teach this country, but on the other hand the American idea of vertical lines was not a new thing—there were people in Italy who built campaniles in the Middle Ages. He hoped that this country and America would go on working out not absolutely new ideas for the benefit of mankind for many centuries, without making any of the very bad blunders which unfortunately their ancestors did make.

Dr. George E. Maclean (Director of the British Division of the American University Union in Europe) said it was important to consider the positive influences which had been drawing together the people of this country and America during and since the war, the normal activities which were not much advertised but which were continuing now with increasing force. The author and his companions in the British War Mission had done a very great work, but what was the permanent outcome in the field of education and especially university education? There was already in operation very much that should be a source of encouragement. British students, graduate students and teachers were going to the United States. Out of the 139 students going to the United States last year, nearly half were British. The movement was being forwarded by the author and the University of Cambridge in the work they had been doing for the advancement of research studies in the establishment of a Doctor of Philosophy degree. He remembered that when the Rhodes Scholarships at Oxford were established, extravagant articles appeared in the British papers about the danger of Americanising Oxford—as if 96 Americans in residence at Oxford could change that University, with its seven centuries of history and glorious traditions and with perhaps 3,000 Englishmen there to keep the balance! What a complete change there had been since 1901! At the present moment there were at Oxford almost as many American advanced students voluntarily attending the University as there were Rhodes Scholars. There was now a magazine published in the United States by graduates of Oxford, who were Rhodes scholars, scattered across the continent of America. He wished to say how thankful Americans were to find the interest taken in Anglo-American relations by such a Society as the Royal Society of Arts and to have such men as Lord Bryce and Sir Geoffrey Butler to further the good relations between the two countries.

Mrs. Burnett Smith said she was one of the very few women on the British War Mission and lived for seven months in America on two separate occasions, intimately in the homes of the people. The pessimistic allusions to Anglo-American relations that were found in the papers left her quite undisturbed, for she had got so deeply down into the heart of the American people that she knew it was sound and faithful and true, she came away from America assured—and had had no occasion since to change her opinion—that as far as Anglo-Saxon ideals were concerned the Americans were absolutely one with the people of this country. She had been much interested in the author's able, subtle and masterly paper. In respect to the enthusiasm of the American people of which the author spoke, she also had been very much struck by it, and it seemed to her that its root was in the youth of the country. Everywhere she went she was confronted by the immense, wonderful and splendid youthfulness of the American outlook, and with all the lovable qualities of youth they had, also some of the faults of youth. They were very impatient of criticism and did not like being ridiculed or made fun of in any shape or form. She thought that on the whole the British War Mission did a great deal of good and did more to reassure the American people about this country than anything else could have done. Her duty in that connection had been to speak for the Food Administration and to urge upon the American people the necessity for food conservation, especially with regard to wheat flour, and they made an amazing response to that appeal. They were not rationed; their food conservation was absolutely voluntary, and it certainly was the most wonderful voluntary abstention that the world had ever seen. The further west she went, in such States as Montana and Arizona, she was very much surprised and touched to find that the attitude displayed there towards Great Britain was very beautiful and totally untouched by any of that lying propaganda which had done so much to undermine the relations between the two countries. She could only ascribe it to the fact, that being so remote from cosmopolitan cities such as New York, Boston and Chicago, and being nearer to Nature's heart, they managed to keep the source of their thought pure and clean. There were certain great emotions and great truths and feelings common to all humanity, and if people could get away from the vile network of propaganda which had nearly parted the two countries she thought they might have absolute confidence about the future. She did not believe that war with America was possible. The more people from this country went to America to get to know intimately the lives and hearts and ideals of the American people, the more hope there was for the future of the relations between the two countries.

Mr. J. H. Douglas, speaking on the subject of the interchange of students between this country and America, said Sir Geoffrey Butler had prophesied a greater flow towards America within the next fifty or a hundred years, and he

was surprised to hear from Dr. Maclean that at the present time there were so many British students attending American Universities. He thought that nothing could bring the two countries to a better understanding and mutual sympathy than personal contact, and personal contact between the younger people of the two countries would certainly be more useful in that respect than any other kind of personal contact that could be arranged. English students should be encouraged to go to the United States. The kind of English student he would like to see in America was the student who had just finished his work at the University and could go to America for one year—just as he was doing at the present time in England—with no definite task that must be carried out but with opportunities of meeting the American people and trying to understand some of their institutions. The sooner more of such students went to America, the sooner the understanding and sympathy that were so desirable between the two countries would be brought about.

Mr. W. A. Appleton (Secretary of the General Federation of Trade Unions) said that, as an Englishman who had visited America on several occasions and had enjoyed American hospitality, and who had been associated with Americans who had been trying to understand him just as he was trying to understand them, he had listened to the paper with the very greatest interest. It must be realised that America was a definite independent nation and capable of working out its own destiny. He thought the mistake was often made of assuming that Americans meant to be offensive when they did not really mean to be so; he had always felt that they spoke with the frankness and vigour and lack of offensiveness of the decent boy, and, taking them in that way, he had never had the slightest difficulty in getting on with the Americans whom he met. He was struck by the suggestion Mr. Douglas had made that English students should go to America without any definite task, but to learn all they possibly could about the Americans and to come back to this country and convey to their countrymen the information they had obtained. He had come to the conclusion that the Americans knew almost less about the people of this country than we knew about the Americans.

On the motion of The Chairman, a hearty vote of thanks was accorded to the author for his interesting paper.

Sir Geoffrey Butler, in reply, said there seemed to be unanimous agreement amongst the speakers who had joined in the discussion that by some means or other English people must be induced to visit America, and personally he was sure that this was *the* need of the moment. An example that it was very desirable should be followed was the endowment of a permanent studentship at Cambridge, in memory of the great Ambassador, Choate, for sending one person annually to the United States. That was the kind of thing that would do more than anything else to promote good feeling between the two countries.

The meeting then terminated.

CORRESPONDENCE.

THE NECESSITY OF UNIVERSITY SLAVONIC STUDIES.

The difficulties attending the study of the Slavonic languages, referred to by Sir Bernard Pares in the *Journal* of May 13th, are due to the irrational systems of transliteration now in use by which the name of a Russian public man is spelt differently in five London newspapers on the same day.

The subject was brought before the notice of the public by the inventor of the Orthotype notation in the *Times*, Russian Section, September 30th, 1916.

The Orthotype notation transliterates phonetically English into Russian letters, and Russian into English letters, without altering the spelling, *i.e.*, the number or arrangement of the letters in either language. The same code is used for both.

In consequence of the introduction into modern Russian print of a degraded Roman type, foreign to the old Slavonic and Cyrillic alphabets, the student is confronted with a printed book which he cannot read, but at best deciphers.

An experiment was made in Ealing with pupils who received instruction for one hour only in the week, and who did no preparation between the lessons. It proved quite successful.

The pupils printed fables, etc., by Tolstoy, by hand in the Orthotype Notation at the first lesson, and no difficulties arose. The hyphen was used to separate the termination and the prefix from the monosyllabic root, as printed by W. H. Lowe in his book, "Russian Roots and Compounds."

For the misleading Roman letters B H P m n representing the English sounds of V N R t p the Cyrillic letters were substituted and no false impression was conveyed to the eye, in either language.

Such transliterations as the ten letters nyedyéilya for a simple Slavonic word of six letters Nedḙla, are absurd to anyone with a visual imagination. The letter "y" here represents a common corruption of human speech, as when the Englishman says "years" when he means "ears." This contraction of the jaws is indicated in Orthotype by the subscript dot instead of the letter "y" which terminates below the line in a dot in ordinary print.

The use of the letter Z to indicate nine different sounds in the Polish Alphabet is another example of the perverted use of the Roman type, which is the shortest and most misleading of all the alphabets, both modern and ancient.

A. D. Butcher.

NOTES ON BOOKS.

Landscape Gardening. By Andrew Jackson Downing. Tenth edition: Revised by Frank A. Waugh. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd. 36s. net.

Andrew Jackson Downing was born in 1815, and died in 1852. At the age of 16 he entered his father's business as a nurseryman, and he soon began to display remarkable gifts in an art that was then but little known in America, landscape gardening. A great part of his work was carried out on private estates in the neighbourhood of New York and Newport, while his most famous public projects were the grounds in Washington about the Capitol, the White House and the Smithsonian Institution. He was one of the first to advocate the provision of public parks in America, and he played a prominent part in the establishment of Central Park, New York.

In addition to his work as a landscape gardener Downing was well known as a skilful writer. His book on "Landscape Gardening," published when he was twenty-six years of age, is generally recognised as a standard work, while among his other works, "Cottage Residences," "The Fruits and Fruit Trees of America," and "Architecture of Country Houses," are widely known. In this new edition of his greatest work, the editor has re-arranged the order, and has introduced a great deal of matter from the Rural Essays, which were first written as articles for the *Horticulturist*, a paper which he edited for some years, and in which much of his best work was published.

It is hardly necessary to describe or criticise here a work which has been so well known for so many years. It is full of suggestion, and while, of course, it is mainly applicable to American conditions, it contains much that should prove helpful and inspiring to British landscape gardeners. Mr. Waugh has carried out his editorial work well, and many will be grateful to him for having brought together, in a single volume, all Downing's principal writings on his favourite subject.

Studies in French Forestry. By Theodore S. Woolsey, jun. With two chapters by William B. Greeley. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. 36s. net.

The vital importance of forests was amply demonstrated in the Great War. It has been said that France was saved by her forests, and this volume is a handsome tribute to the efficiency of the French Forest Service. The material for it was collected to a large extent in 1912, but the author's service in the Corps of Engineers, U.S.A., while it delayed the completion of the work, no doubt added enormously to his experience of the French service and to a full appreciation of its excellence.

The greater part of the volume describes the methods of work and the general policy adopted by the French State in the conduct of their forests; and this section should prove of special value and interest in this country just now when our new Forestry Commission, under the able chairmanship of Lord Lovat (who himself gained great experience and rendered invaluable service in France as Director of Forestry of the British Expeditionary Forces) is for the first time developing a forest policy for the kingdom and, through the Imperial Forestry Conference, for the British Empire.

Excellent, however, as this account of the French service is, one feels tempted to turn to Mr. Greeley's chapter on "The American Forest Engineers in France." One of the first requests for help from the United States by both French and British Governments was for regiments of trained lumbermen. Forty-nine companies of forest and road engineers, each 250 men strong, were sent from America to France. By the date of the Armistice the Forestry Section numbered 12,000 engineer troops, and 9,000 service troops. They operated from eighty to ninety saw-mills and employed some 3,600 draft horses and mules. The demand for timber was enormous. Vast amounts were required for camps, hospitals, shops and warehouses, while in every advance large supplies were necessary for railway ties, bridge timbers, road planks for throwing forward quickly built roads over streams and shell-torn ground, and further quantities were used up in constructing trenches and fortifications. The American Army alone, which numbered about 2,000,000 men, used up 450,000,000 board feet of round or manufactured timber, and 650,000 cords of fuel wood. The most difficult requirement to fill was the need for 39,000 piles, in lengths up to 100 feet, which increased chiefly in the docks built by American engineers at various French ports. Six per cent. of the total covered the demands for telephone and telegraph poles, wire entanglement stakes, and pickets for supporting camouflage nets.

An interesting account is given of the methods adopted by the American lumbermen in transporting timber. Some idea of the size of this problem may be gained from the statement that a single officer in the Landes district moved about 100,000,000 feet of timber over a single railroad system in a year. A tribute is paid to the excellence of the French forest roads, by which fleets of motor trucks and trailers were enabled to haul enormous loads, while caterpillar tractors did wonderful work over ground which was impassable for horses.

Mr. Greeley, like Mr. Woolsey, speaks eloquently in praise of the wisdom of those who have guided the forest policy of France. "Probably never in the history of the world," he says, "has the forest policy of a nation

been so clearly vindicated as was that of France by the War of 1914. Wood was one of the most vital military necessities, and the allied armies drew the great bulk of their supplies from the forests of France. . . . France could have kept on supplying the vast armies on her soil for one or two years more, if need be, without cutting seriously into her forest capital. Without these ample reservoirs of timber, the transport difficulties being what they were, the handicap which the allied armies would have suffered would have been almost insurmountable. Apart from its value to her peace-time life and industries, the forest policy of France has been indicated as a capital element of national strength in the greatest crisis of her history."

THE ARTIFICIAL FLOWER INDUSTRY IN ARGENTINA.

The manufacture of artificial flowers has been carried on in Argentina for more than two decades and was in a very flourishing condition until a few years ago. Since then there has been a noticeable falling off in the demand for these flowers, due, it is claimed, more to the general desire of the public to economise in their purchases of non-essentials than to any permanent change of attitude toward their use. There are no separate statistics by which to judge the value of the present annual production, but competent persons who are engaged in this business estimate that it is approximately 500,000 pesos (paper) (about £44,000) or one-half of the sales in 1913.

Artificial flowers are employed chiefly for household decoration, wedding, and religious ceremonies, millinery and dress ornament. Many small shops make a speciality of letting on hire wreaths and other set pieces for temporary use on formal occasions; in this way a small output is made to serve a relatively large demand. For the most part, however, the flowers are bought outright, and a great many are made up according to design for a particular person rather than for general stock. The quality of workmanship is high, although there is no great abundance of skilled labour, and some very fine examples of the flower makers' art are displayed by the better factories. There is also an extensive home production as flower making is taught in many schools for girls.

According to a report prepared by the U.S. Trade Commissioner in Argentina, all of the materials for this industry are imported, and practically without exception they come from Europe. It is generally considered that the best work in preparing the raw materials, as in making flowers, is done in France; consequently there is no disposition to look elsewhere for goods. Other European countries occasionally contribute to the Argentine market, although their articles nearly always come through French houses who purchase in Austria, Germany, Holland, Italy, or wherever certain products can be secured.

The principal goods used in this industry consist of cambric, which is the basis of most of the flowers, special cloths, such as satin, silk, velvet, tulle, leaf material, and crepe paper, silk paper, stem tubes, gum arabic, gilt leaf, and tinsel, bare or covered wires and aniline dyes. The cambric comes from England. It must be so prepared that the stiffening materials do not soften or run in damp weather. Crepe and silk paper must be of sufficient strength to withstand considerable manipulation before tearing. The aniline dyes come in powdered or liquid form and are all of German make.

In addition to the foregoing, there are certain parts already made up which the industry finds it to its advantage to import rather than to manufacture. Among these may be mentioned flowers of especially fine quality, seeds, buds, thorns, small fruits, moss and foliage. Metal leaves and petals are used largely for funeral wreaths. Gilt and silver foil for making up church ornaments have a continuous demand. There is also a sale for all kinds of cheap tools such as leaf and petal dies, ball irons, moulds, presses, pliers, etc.

SHARK FISHING IN LOWER CALIFORNIA.

The shark-fishing industry is becoming increasingly important in the Ensenada district, writes the U.S. Consul there. The Lower California shark, known locally as the dogfish shark, is from 4 to 5 feet long and weighs from 90 to 125 pounds. The fishing is usually done by individual fishermen working out from camps on land. The fish are caught on long set lines, on which are 50 to 100 hooks baited with small fish or lumps of shark meat. These lines are secured to floats, and the fisherman visits the lines daily to remove the catch.

The fins are sold for consumption by Chinese in shark-fin soup. The liver is boiled down and shark oil rendered out; each liver gives an average of 1 gallon of oil. This oil is used in paints and as a leather preservative. The remainder of the fish is dried and made into fertilizer or chicken feed. The skins are not utilized, except for fertilizer. Frequently shark steaks are sold by Chinese in the district under the name of grayfish.

The large canning factories working fish-fertilizer plants in San Diego (California), are eager to buy shark, and the newly finished plant at Sauzal, Lower California, expects to specialize on converting shark into fish-meal fertilizer. Whereas formerly sharks caught in nets were separated from the more valuable fish and returned to the water, they are now

brought ashore, although the demand is not yet sufficient to warrant using nets for sharks exclusively.

BUILDING BLOCKS FROM CLINKERS.

A Brest industry, which suspended operations during the War but which has now re-started working, is that of the manufacture of building blocks that are gaining widespread usage in certain kinds of building construction in the district. The blocks are made in moulds, the materials used being sand, lime, and cement, with a base of crushed coal clinkers. The lower grade of blocks also contain some coal cinders. These blocks are made in several sizes.

The clinker building blocks are particularly used in pavements, walls, floors of cellars, warehouses, stables, garages, rough buildings, and small residences. The blocks have the advantage over brick for building material in that they are cheaper and facilitate quick construction. They take plaster on the interior and stucco on the exterior where it is desirable in buildings.

However, the outstanding advantage of the clinker block over the brick in the Brest district, writes the U.S. Consul at that port, is the capacity of the former to withstand the great humidity of the climate there, which causes brick walls to drip water in the interior of houses.

MEETING OF THE SOCIETY.

Indian Section.

At 4.30 p.m.

Friday, June 10.—Sir George Seymour Curtis, K.C.S.I., Member of the Executive Council, Bombay, 1916-21, "The Development of Bombay."

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

Monday, June 6..University of London, University College, Gower Street, W.C., 5.30 p.m. Dr. C. Porter, "Recent Developments in Legislation for the Prevention of Disease." (Lecture III.)

Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Rev. Prebendary H. E. Fox, "The Roman Wall of North Britain."

Royal Institution, Albemarle Street, W., 5 p.m. General Monthly Meeting.

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m. 1. Dr. Leonard Levy, "Industrial Respirators." 2. Prof. K. G. Naik, "The Gold and Silver Thread Industry in India."

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C., 5 p.m. Annual General Meeting.

Tuesday, June 7..University of London, 8, Hunter Street, W.C., 5 p.m. Mr. J. A. Gardner, "Metabolism of Cholesterol and the Sterols." (Lecture IV.)

Royal Institution, Albemarle Street, W., 3 p.m. Sir James Frazer, "London Life in the Time of Addison."

Alpine Club, 23, Savile Row, W., 8.30 p.m.

Zoological Society, Regent's Park, N.W., 5.30 p.m. 1. Dr. F. M. Chapman, "The Distribution of Bird-life in the Urubamba Valley of Peru." (Illustrated by lantern slides.) 2. Mr. S. Maulik, "New Indian Drilid Beetles." 3. Prof. J. P. Hill, "Exhibition of some Marsupial Embryos, especially the Koala and the Wombat." 4. Mr. R. I. Pocock, "The External Characters of the Koala (*Phascolarctos*) and some related Marsupials." 5. Dr. C. F. Sonntag, "The Comparative Anatomy of the Koala (*Phascolarctos cinereus*) and the Vulpine Phalanger (*Trichosurus vulpecula*).

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8 p.m. Sir John Findlay, "The Future Government of the Empire."

Wednesday, June 8..University of London, South Kensington, S.W., 5.15 p.m. Dr. A. D. Waller and Mr. J. C. Waller, "Experimental Studies in Vegetable Physiology and Vegetable Electricity." (Lecture IV.)

Geological Society, Burlington House, W., 5.30 p.m.

Oriental Studies, School of, Finsbury Circus, E.C., 12 o'clock. Miss A. Werner, "European Expansion in Africa." Lecture VII.—Portugal and Nyasaland.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. (Wireless Section.) Prof. J. S. Townsend, "Electric Oscillations along straight Wires and Solenoids."

Thursday, June 9..Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Mr. W. M. McGovern, "The Buddhist Literature of China." (Lecture IV.)

British Architects, Royal Institute of, 9, Conduit Street, W., 5 p.m. Mr. H. S. Goodhart-Rendel, "Some Fashions in Architecture."

Paint and Varnish Society, St. Bride's Institute, Bride Lane, Fleet Street, E.C., 7.30 p.m. Mr. C. A. Klein, "The Need for Science and Common Sense in the Practical Testing of Paints."

Royal Institution, Albemarle Street, W., 3 p.m. Sir Alexander Mackenzie, "Beethoven." (Lecture II.)

Historical Society, 22, Russell Square, W.C., 5 p.m. Dr. Emilio Re, "The English Colony in Rome during the 14th Century."

Mining Engineers, Institution of, at the Geological Society, Burlington House, W., 11 a.m. 1. Mr. J. P. Rees, "Third Report of the Committee on 'The Control of Atmospheric Conditions in Hot and Deep Mines:' Observations of Temperature and Moisture in Deep Coal Mines." 2. Prof. H. Briggs, "Characteristics of Outbursts of Gas in Mines." 3. Mr. H. C. Harrison, "The Use and Distribution of Shale Dust in Mines." Discussion on the following Papers: (a) Messrs. A. E. Beet and A. E. Findley, "The Better Utilization of Coking Slack." (b) Mr. J. Ivon Graham, "The Normal Occurrence of Carbon Monoxide in Coal Mines." (c) Mr. T. L. Galloway, "An Improved Method of Determining the Relative Directions of Two Reference Lines or Bases for Mining Surveys." (d) Messrs. E. Bury, W. Broadbridge, and A. Hutchinson, "Froth Flotation as Applied to the Washing of Industrial Coal."

Friday, June 10..University of London, University College, Gower Street, W.C., 5.30 p.m. Dr. C. Porter, "Recent Developments in Legislation for the Prevention of Disease. (Lecture III.)

At King's College, Strand, W.C., 5 p.m. Prof. H. E. Armstrong, "Enzymes in Relation to Plant Growth." (Lecture II.)

Royal Institute, Albemarle Street, W. 9 p.m. Dr. A. G. Webster, "Absolute Measurements of Sound."

Astronomical Society, Burlington House, 5 p.m.

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Saturday, June 11..Royal Institution, Albemarle Street, W., 3 p.m. Mr. R. S. Rait, "Scott and Shakespeare." (Lecture II.)

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FRIDAY, JUNE 10, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

TWENTY-THIRD ORDINARY MEETING.

Monday, May 30th, 1921; THE RIGHT HON. J. R. CLYNES, P.C., M.P., in the Chair.

The following Candidates were balloted for and duly elected Fellows of the Society:—

Boyd, James, Montmagny, Canada.
Duclos, The Hon. J. A., Port Louis, Mauritius.
Flagner, Harry Harkness, New York City, U.S.A.
Kafuku, R., Osaka, Japan.
Neill, Charles, Singapore, Straits Settlements.
Vernon, The Right Hon. Lord, Derby.
Wilkinson, George Henry, C.C., London.

A paper on "Immunity and Industrial Disease" was read by Sir Kenneth Weldon Goadby, K.B.E., Medical Referee for Industrial Poisoning, County of London.

The paper and discussion will be published in a subsequent issue of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

INDIAN AND COLONIAL SECTIONS.
(JOINT MEETING).

FRIDAY, MAY 27TH, 1921.

THE RIGHT HON. LORD SOUTHBOROUGH, P.C., G.C.B., G.C.M.G., G.C.V.O., K.C.S.I., in the Chair.

THE CHAIRMAN said he doubted very much whether it was necessary for him to introduce the author of the paper to the Society, but it was necessary to impress upon those present the great position which Sir Charles Bedford held, particularly in connection with the subject which they had met there that afternoon to discuss; that they should be so impressed was, in the nature of things, part and parcel of the virtue of the paper. Sir Charles Bedford commenced his connection with the subject under discussion over twenty years ago. The Government of India selected him eighteen years ago to conduct their enquiry into alcoholic liquors in India. The resulting experimental enquiry necessitated full analysis of every variety of alcohol produced or imported into India. It had also entailed a complete physiological study of the effects of the impurities or by-products of spirits and of manufacturing methods there. Further, Sir Charles, as the expert adviser of the Government of India, had had to investigate a number of technical excise and customs questions, and his knowledge of that branch of the subject would be of great importance when the policy of his paper was put into operation. His report to the Government of India of 1906 was of permanent value. It became to such a keen judge of evidence as the late Lord James of Hereford, his Bible, as he described it, when Chairman of the Royal Commission on Whisky and other spirits. A similar compliment was paid to Sir Charles by Sir Mackenzie Chalmers, who acted as Chairman of an important Commission which studied the alcoholic position in Nigeria. He (the Chairman) would like to mark the point that Sir Charles Bedford's work had been of universal and of real practical value. At one time he was found correcting hydrometer tables that had been good enough for King George II., but which had not satisfied Sir Charles, with the result that he had made very important corrections in those tables, and his amendments had brought in a largely increased revenue for the benefit of the Government of India. At another time he created for himself the gratitude of the Government of India, but much less satisfaction on the part of the consumer, by inventing methods of making spirits non-potable, by putting into them the nastiest stuff that could be imagined. That subject, of which Sir Charles would tell them more, was really of the very essence of the problem which they were met to discuss, because unless alcohol could be put upon the market at a cheap rate, which meant that the spirit duty on industrial alcohol was taken off, it would be quite impossible to pursue that line of industry to a successful commercial issue. In all those things Sir Charles Bedford had been a successful pioneer. He had had more success than was generally given to the pioneer. He was now directing his abilities to a new branch of the subject; in fact, alcohol had absorbed Sir

Charles for 20 years, but it had done him no harm. It had apparently filled him with power and with force. He now asked Sir Charles to start upon his voyage, to exhibit that power and force, and to carry all of them to a destination full of public benefit and commercial prosperity.

The paper read was

INDUSTRIAL (INCLUDING POWER) ALCOHOL.

By Sir Charles H. Bedford, LL.D., D.Sc.,

Chairman, Sub-Committees on Denaturation and on Alcohol Excise Restrictions, Empire Motor Fuels Committee of the Imperial Motor Transport Council; late Director, Central Excise Laboratory for India, and Chemical Examiner to the Government of India, etc.

In any survey, however brief, of the subject of establishing within the British Empire a great new Industrial Alcohol industry the subject-matter would appear to fall under four main headings :—

I. The Production of Alcohol in assured and sufficient quantities at the lowest possible cost.

II. The Denaturation (or rendering unpotable) of the Alcohol so as to secure relief from the prohibitively heavy duties levied on potable spirits.

III. Removal or modification of many of the existing Customs and Excise restrictions on Industrial Alcohol during its manufacture, storage, distribution and retail—such restrictions adding greatly to the cost of the article.

IV. Modifications of the internal combustion engine to obtain the best results with Alcohol, alone or in admixture with other substances such as benzol or petrol.

I deal with these *seriatim* :—

Production of Alcohol This is the paramount consideration. For many years past the long-suffering public in this and other countries has been tantalised by visions of cheap and abundant alcohol as an alternative to petrol and other mineral light fuels. The newspapers from time to time announce some new means of obtaining alcohol for a mere song, but, unluckily for the public, these dreams do not materialise. Our well-known contemporary, the Man-in-the-Street, appears to believe that alcohol is freely producible from nearly everything, with the possible exception of paving-stones. Unfortunately he overlooks the fact that, for successful commercial exploitation, it is not only necessary to have a substance from which you can make alcohol, but also one from which you can make money. No attempt can be made to review to-day the technical and commercial possibilities of the large number of raw materials which have been used, and proposed for use, for alcohol production, as I should explain that—apart from the fact that this would require a separate lecture—I have only within the last few days returned to this country from Burma after a six months' absence on business connected with the large scale production of Industrial Alcohol. I have consequently had no opportunity since my return to attempt to collate the facts regarding the present position of the Alcohol movement in the Overseas Dominions of the Empire—a task obviously involving prolonged enquiries and correspondence with the countries in question and which is accordingly out of the question under the present circumstances. I have not touched on projects still unproved commercially, such as synthetic production and bacterial treatment of cellulose (vegetable) materials, preferring to await more definite issues in such matters.

Hitherto in *the United Kingdom*, industrial alcohol has been almost entirely made from molasses and grain (maize chiefly). There are no better sources if you can get them cheaply enough. At the present moment, the prices of both are prohibitive for alcohol manufacture on the large scale. In this country insufficient acreage, high cost of cultivation and manufacture, and the use as foodstuffs of the obtainable raw materials make the situation at present hopeless. In *the United States* cane or black-strap molasses and Indian corn have been mainly used for this purpose. In looking through for this paper a pamphlet published in 1910, by Dr. H. W. Wiley, Chief of the Bureau of Chemistry of the Amercian Department of Agriculture* it was interesting to find the following remarks which bear closely on the subject I wish to speak to you about presently, viz., Alcohol production from straw and other waste or semi-waste vegetable materials. Dr. Wiley pointed out that, apart from the grain itself, if the green Indian corn-stalks, *i.e.*, the stalks obtained when the green corn is harvested, were used the United States could make enough alcohol to furnish all

* "Manufacture of Denatured Alcohol": U.S.A. Agriculture Department. Bulletin No. 130.

that would be needed for power, light and fuel (presumably in the United States only). There were at that date in the States about 100,000 acres under corn, averaging 8 to 10 tons per acre, which would furnish 100 lbs. of alcohol per acre. This amount goes to waste every year. The cost of the various cereals (rice, barley, rye, Indian corn, oats, etc.) most of which can be, and have been, used for alcohol manufacture is the limiting factor. Cuba and Porto Rico are important suppliers of the molasses which is used to a very considerable extent in the U.S.A. Sorghum, rice, etc., are also used in very small amounts. Indian corn has hitherto been for potable as for denatured alcohol, a favourite raw material there.

Crops which have been damaged by frost, heat, moisture or mould, are quite suitable for denatured alcohol manufacture, being cheap and efficient, but the supply is obviously too uncertain in occurrence and geographical distribution to be able to depend much on this source. The maximum production of denatured alcohol was, in 1917, 93,762,422 proof gallons and of this amount over fifty million gallons were for explosives and other war purposes. Great attention is being paid to power alcohol development in the U.S.A., for, as the American Geological Survey has pointed out, within two years from now "the peak in a curve showing petroleum production will be reached and after that time there will be a gradual decline in petroleum production over a long period of years." This in conjunction with the increase in the fuel demands for motor vehicles of all kinds points to difficult times ahead. At the moment there has been a slight setback as to this but the check can only be temporary. Meanwhile standard engines are being used with excellent results with mixed alcohol fuels.*

In Germany, as we probably all know, the potato is the chief raw material used in industrial alcohol manufacture, and the late German Government's system operated so as to favour :—

(*a*) The agricultural class of distilleries working in rural districts and returning all by-products to the soil.

(*b*) Potatoes as a raw material rather than molasses, beets, etc.

(*c*) The small distiller rather than the large distiller ;

(*d*) The production of industrial at the expense of potable alcohol ;

(*e*) The producers and users of industrial alcohol (by the payment of a large part of the expenses of the Government supervision, and by means of the remission by preferential bounty of the graduated alcohol taxes) ; and

(*f*) Alcohol yield was stimulated by taxation on the volume of the mash.

The industrial alcohol industry was only a part of a comprehensive paternalistic scheme of internal development and soil improvement somewhat similar to the highly successful fostering of the beet-sugar industry by the German Government.*

In France the beet is perhaps the characteristic raw material for industrial alcohol production along with molasses and grains.

The foregoing instances may very briefly and baldly serve to illustrate the position as regards alcohol producing materials hitherto used in the larger countries of the world, and we now come to the question of the immediate prospects of cheap industrial alcohol production on a sufficiently large scale and with special reference to the British Empire.

Nothing perhaps could better illustrate the present position as regards the United Kingdom and some of the Crown Colonies than the recent activities of the largest and perhaps most progressive Distillery Company in this country. Recognising the hopelessness of large scale manufacture of industrial alcohol here, they have sent expert representatives from their Board to various parts of Africa, to British Guiana, to Fiji and elsewhere to ascertain the possibilities of developing successfully in these various countries alcohol manufacture on a sufficiently large scale. It is understood that their enquiries have been more especially directed to the raw materials (sugary and starchy) with which they have had long working experience, namely, molasses and grains, and that the results hitherto have been very discouraging.

They have apparently found that (even apart from labour and transport difficulties) raw materials which have a use as foodstuffs fetch a market price which precludes their economical use as sources of industrial alcohol. I ventured, in an address given

* "The Future of Industrial Alcohols," by B. R. Tunison, Journ. Indust. & Engin. Chem. Apl. 1920.

* "Denatured Alcohol": U.S.A. Commissioner of Internal Revenue, 1909.

at the recent Imperial Motor Transport Conference held last October at Olympia, to state: "It is necessary to rule out all raw materials which have a food value or, indeed, any particular value in the general market for other purposes than that of alcohol manufacture." At that time I somewhat modified this statement to the extent of making a possible exception chiefly in the case of regions where food materials could not be readily marketed and where an excess could be grown (over local and other food-market requirements) for utilisation as sources of alcohol.

It may be possible to work in co-operation with the local farmers in some particular regions so as to obtain from them at least a portion of their crops suitable for alcohol manufacture. But schemes which contemplate the reclamation of waste lands and placing them under crops fitted for alcohol production have usually to face the difficult problems of the suitability of rotation crops and the possibility of marketing such advantageously. The practical question is, will the farmers agree to grow such crops? In some cases, the rotation is often one covering four or five alternative crops, and the area of land required to furnish the alcohol producing fraction of such rotation crops must necessarily be considerable. Another difficulty with which the use of food substances for alcohol production is faced is that in certain countries—one can speak with direct knowledge of India and Mexico—the Governments restrict or forbid the use of foodstuffs for any such purpose. In India, in the frequently recurring food shortages and actual famines, the Government would certainly impound any foodstuffs being used for industrial purposes such as alcohol manufacture. In many tropical countries labour conditions are often either impossible (as has been found recently in Fiji and in parts of tropical Africa) or are otherwise too costly and precarious. Transport difficulties and costs, in many cases, present great difficulties or make the proposition hopeless financially.

In view of such considerations, the result of the enquiries overseas by the chief distillery interests of this country are distinctly disappointing, especially as it is most desirable that the agencies for alcohol manufacture should as much as possible be spread over the whole Empire, primarily for the benefit of the populations of the producing countries, and secondarily for the limitation of possible monopolistic or controlling efforts on the part of certain very powerful financial interests. One has so far been compelled to paint a somewhat gloomy picture of the prospects of Empire production, but fortunately there is a silver lining even to this cloud. I have been entirely engaged for the last two years in the investigation of certain new raw materials which are waste or semi-waste in character, and which are obtainable in practically unlimited quantities within the confines of the British Empire. Since 1914, when, as Director of Investigations of the Alcohol Motor Fuel Committee of the Imperial Motor Transport Council (which made a vigorous start two months before the War and which only the outbreak of war brought to an abrupt end for the time being), one had occasion first to study the Empire conditions as regards raw materials for alcohol production, the conclusion has been increasingly forced on one that attention should be concentrated on waste vegetable materials rather than on foodstuffs. I had for some time past contemplated the use of elephant or Savannah grasses and of (chiefly) immature bamboos as a joint source of alcohol and of paper; and I have during the last two years initiated and directed experimental work on the distillery and laboratory scale on both of these.

In 1918-19, when free from war-work and able to resume work on the alcohol problem, the idea of employing rice-straw for making alcohol was first proposed to me by Mr. Arthur Rogers, C.B.E., and we agreed jointly to patent a process for the purpose. I was entrusted by Mr. Rogers with all further work in the matter, he resting content with the initiatory proposal of rice-straw as a raw material. I then proceeded to consider the most likely sphere for operations, and decided on Burma on account of the fact that rice (an annual crop covering a large acreage) is the staple commodity there and that the rice is grown chiefly in an immense deltaic region freely intersected with tidal waterways, furnishing the cheapest form of transport for bringing the raw materials to the distillery and for removing the finished products to convenient marketing centres or ocean ports. The next step was to secure the necessary financial support to complete large manufacturing-scale

experiments on the spot so as to prove beyond all reasonable doubt that rice-straw was a practical commercial source of alcohol. I was fortunate enough to secure the support of the Burmah Oil Company for this purpose. My next step was to erect a distillery and the requisite laboratory and other adjuncts at their refineries at Rangoon and the necessary experimental work has been carried out in England, and there, and is still in progress but should now shortly be far enough on for initial requirements. For obvious reasons it is impossible to enter into details as regards the commercial side of the scheme, but what has been stated above constitutes no indiscretion and is merely knowledge common to all interested in the matter here and in Rangoon, and which has even appeared in the press of various countries.

The raw materials to be used are not confined to rice-straw, but several others (obtainable locally and at various times of year in the requisite amounts) will also be used so as to keep the plant operating throughout the year. It may now be said with safety, that the result is satisfactory (and it is also the considered opinion of the various leading commercial and technical experts in England and France with whom I have been in touch) and that there is no doubt that alcohol can be made from rice-straw on commercial lines under the conditions employed. There are special features in this scheme which allow of the production of very valuable by-products (hitherto unused) which will very materially reduce the cost of the production of alcohol. The method of manufacture has been simplified, in the course of our work, so as to give a low cost of production. Costs of raw material, fuel, fresh water supply, labour and transport difficulties have been placed on a satisfactory basis. The matter has not yet been placed officially before the Burmah Oil Company's Board pending certain further requirements, but I hope shortly to do so. I have now said as much as I can without indiscretion. The fact is that such a scheme as this is only possible to a big capitalised concern, as paper and alcohol must be worked simultaneously, on a sufficiently large scale and there is (so far as I am able to judge at first hand) no room for more than one such venture of the requisite size for practical success in Burma, owing to very special conditions of limitation of supply and transport of the raw materials there, and other considerations.

At the same time I wish strongly to emphasise the necessity in the public interest for continuing and extending this work of exploiting other waste vegetable materials, which occur in practically inexhaustible amounts throughout the British Empire. It is not yet generally realised that, just as we have been hitherto passing through the Coal and Oil Eras, we are now on the threshold of the Cellulose Era (cellulose being the basis of such vegetable materials). There is, so far as I know, no systematic attempt being made at present to study and exploit the waste cellulose materials throughout the Empire. If a comparatively small sum of money annually were to be devoted to systematic practical work—large scale as well as laboratory—on the utilisation of waste vegetable materials for power production (as producer gas, charcoal or alcohol) the return yielded as regards industrial development and the general welfare would much more than justify the outlay. When we consider how essential cheap motor fuel is to the development of our Empire, and how prohibitive is the cost of mineral light fuels in many of these oversea lands surely we have a case for intensive and thorough investigation—both central and local— of the requirements of the situation.

It is now an accepted axiom of Governmental administration that it is a legitimate, indeed necessary, sphere for State action to subsidise the experimental work requisite for the development of vital communal interests. The Department of Scientific and Industrial Research in this country represents the Government's attempt to give effect to this policy, and we welcomed the appointment in 1920 of Sir Frederic Nathan as the first Power Alcohol Investigation Officer, attached to the Fuel Research Department. There are, however, distinct limitations to the practical usefulness of such an official organisation as this last, and its chief value would now appear to be as a useful link between the Government and the industrial agencies endeavouring to bring into actual commercial operation schemes for the production of alternative fuels.

There is certainly also a limit to the extent of co-operation between the industrialists concerned in developing such new schemes—a limit which experience shows is

speedily reached—but by amalgamation some degree of joint action between the various interests should be secured. No one wishes for a moment that Government should subsidise or control the manufacture of industrial alcohol, but what we may reasonably and properly ask of Government is to aid in the promotion of practical work to further the development of the industries and communal wants of the countries under their control by all possible concessions and relaxations of unnecessarily restrictive Departmentalism. For undeveloped countries (even if comparatively roadless or with a poorly developed road system and few rail or water transport facilities) the question of motor transport is one of great importance. Many forms of commercial and other tractors and vehicles can of course operate in countries where the road system is undeveloped and to the great advantage of the community in general. Many things have epigrammatically been asserted to constitute civilisation, but transport facilities are admittedly one of the most obvious of these.

Is it too much to hope for the initiation of measures now to further the development of sources of power, light, heat, etc., from waste vegetable materials and for a systematic exploration of cellulose possibilities, in view of the unlimited supplies available and the universality of these throughout the British Empire? Certainly there is no sphere of activity for real constructive statesmanship and for industrial enterprise more important than this. Let me, in this connection, quote the words of one of the most trusted and respected of His Majesty's late Ministers, Mr. Walter (now Viscount) Long, then First Lord of the Admiralty, when on October 18th last he acted as Chairman at the meeting of the Empire Motor Fuels Committee at which Professor Dixon, of Manchester, read his paper on "Researches on Alcohol as a Motor Fuel":—"If I were an idle man and had nothing else to do and was looking about for an occupation I do not know of anything that would attract me more than to devote my energies and any abilities that I might possess to this cause of improving the supplies of either petroleum products or their substitutes. I ask you to try and imagine for yourselves what the range of vision is. . . . . Alcohol, I am informed, as a source of power must be examined and re-examined and I am sure that the scientific brains of the Empire must devote themselves to discovering methods of supply on commercial lines. It has been suggested in some quarters that Government should subsidise an industry for alcohol production, but I venture to express an opinion . . . that I think the less Government control and subsidise, in such a matter . . . the better. What Government can I think do, and is doing, is to set up experimental works to indicate the lines upon which an industry can be established. . . The problem is not an easy one, and it requires the concentrated efforts of everybody who is interested in the subject—and surely that means the whole community."

It is the opinion of the Empire Motor Fuels Committee that for real progress along safe lines we require the co-operation of various interests. One of its members, Mr. W. H. Ross, Managing Director of the Distillers' Company (which controls about 85 per cent. of the distilling industry in this country) in opening one of the discussions at the 1920 Motor Transport Conference at Olympia said:—

"My feeling is that if this project is to be a success at all we must have co-operation with other sources, co-operation with the oil companies, with the benzol manufacturers, with the motor users and with the distillers. Only on that basis, I think, can we hope to have a scheme of sufficient magnitude to do any good in supplying the present alarming shortage which we are told is in course of being experienced in the petrol market. I hope, therefore, that when the matter is fully investigated and it is found that alcohol can be produced on a moderate price basis in those distant markets, some scheme will be introduced which will embrace the whole of those interests I speak of, and not to have competition amongst the various interests in a way that would probably destroy the trade for all time."

In following Mr. Ross in the same discussion, I ventured to state:—"The point which Mr. Ross has made is one which, I think, we must face. We want a combination of industries, not from a monopolistic point of view, because I am fairly certain that no Government or any community is going to see alcohol follow what we are led to understand has been the course of the evolution of benzol, *i.e.*, a moving up of benzol prices in conjunction with

petrol. Well, the public I do not think will be likely to stand that another time in the case of alcohol. . . . We want to get all these business interests together and cut down overlapping competition and all the costs connected with it.''

Now, let us try to see to what extent these aspirations are realisable. The first difficulty is that each of these interests is not unlikely to prove to be like the Dutch, rather too fond of ''giving too little and wanting too much;'' but that is, within limits, only what one must expect from keen business organisations, which are not (and are never likely to be) inspired by altruism or kindly consideration for the community in general. What has each of the great interests specified by Mr. Ross to offer to such a common scheme ?

The Distillers have long experience of their own trade and technical conditions, and have a ready-made staff of commercial and technical experts, as also a certain amount of capital as their possible contribution.

The Oil Companies however have far larger financial resources than the distilling and other interests concerned with which they could easily float and maintain a great alcohol industry (with its essential adjunct of paper manufacture where certain of the raw materials are concerned). They also have control of all the requirements for the bulk-handling and transport of alcohol. The tank-steamers and waggons, storage tanks and distributing organisation for oil are equally available for alcohol, and here is a ready-made organisation to hand for the new industry. The oil companies may, if I read aright the signs and portents, prefer to offer distributing, transport and storage facilities for any new large scale alcohol enterprise, and may be reluctant to finance its production until they see how matters shape with the new industry. At the present time I fancy—and this is a purely personal view—their attitude may be this :—Here is a proposition which, though it cannot assume large or threatening proportions in relation to us for several years to come, must be closely watched. If we offer distribution facilities and find that alcohol is seriously encroaching on our domain, we can easily control alcohol prices by putting up our distribution costs for the commodity sufficiently to prevent effective competition with petrol. Let others take the risk of financing a new and for that reason necessarily somewhat uncertain industry while we will control it, when produced, through distribution; and in this way also add to our revenues without risk or trouble to ourselves.''

I venture to say that while this attitude is perhaps a natural enough reaction to what may ultimately prove a menace to present oil interests, it may prove to be in the long run a very short-sighted policy.

Alcohol should be regarded not as a substitute for petrol, but as a supplementary or alternative substance to be used (for many years to come) as a conserver of petrol supplies. Many of the oil companies are rightly concerned about the continuance of their yields of oil. If alcohol conserves the supply of oil fuels, surely it closely subserves the interests not only of the oil companies, but of the whole community. In that case, it appears that the far-sighted policy is to use every endeavour to promote alcohol production and to combine the interests of such with oil production. Here again, supposing the oil companies come to adopt this point of view, there will arise the question of predominance over the other interests. If the oil companies are to contribute the major part of the capital required for alcohol development, and are to supply also the essential bulk-storage, transport and distributing facilities, that would obviously give them very strong claims in relation to lesser groups in any combine. Indeed, if the oil interests decide to come whole-heartedly into alcohol production, they can easily afford to ignore in effect, and to make themselves independent of, the other interests such as the distillers, benzol manufacturers and motor manufacturers and users, for there is no good blinding ourselves to the fact that they can obtain independently all that the others have to offer.

The benzol interests are a comparatively small section and in the restriction of output of coal with which we seem to be confronted, in this country for several years to come, and the necessity for keeping up the quality of coal gas (which militates against stripping the gas of benzol) they have apparently a difficult time ahead. The great use of benzol may in the future come to be as an adjunct motor fuel—a very useful ingredient in mixed alcohol and oil fuels. In any case, the amount of benzol likely to be marketed in this country in the years immediately ahead, would appear to be

insufficient to make it a really serious competitor of oil fuel or, later on, of alcohol. If, then, the benzol interests found it to their advantage to join such a combination as I have mentioned, they could not look for a relative position in excess of their contribution to the effective interests of any such scheme.

Lastly, we come to consider *the Motor organisations — Manufacturers and users.* There is very little doubt that this group, if it were so minded, could develop very serious powers of resistance to domination of the motor fuel situation by the oil interests. But it would be a gigantic undertaking and one on which, if one may venture to offer a conjecture, they would be exceedingly reluctant to embark. In any case, it surely would be disastrous to attempt to inaugurate a great new alcohol industry in face of the hostility of the rich and powerful oil interests. Hence compromise and attempts at co-operation are obviously indicated.

We therefore return to the position independently arrived at by the Empire Motor Fuels Committee, and voiced by Mr. Ross, that in the interests of all concerned we must get together and collaborate, if at all possible.

It seems that the first stage should be a concerted effort to combine the various interests so as to deal practically with the problem of furthering the production of alcohol from waste vegetable sources, from which it is now an ascertained fact that it can cheaply and effectively be produced, and to search for, and commercially and technically investigate, other such raw materials. The whole position is now modified by the fact that the solution of the problem of the production of alcohol in sufficient quantity and at a reasonable cost lies ready to our hand if we systematically develop its manufacture from the various waste or semi-waste vegetable materials which occur throughout the Empire, in unlimited and frequently renewable quantities. This is no visionary dream but an experimentally ascertained fact. The only proposal I can formulate at the moment is that an attempt be now made to bring together the great interests mentioned to form a preliminary syndicate for extended experimental work (on the likeliest raw materials available within the Empire) and on the large scale as well as on the laboratory—for both are closely interdependent and essential. Such an organisation, *if thought desirable*, might then comply with the requirements for Associational research, and claim the pound-for-pound subsidy from the Department of Scientific and Industrial Research. Personally, I would prefer to see the work entirely financed and controlled by this preliminary commercial organisation without financial State aid. Following on the findings of such enquiry a commercial organisation might then be formed to exploit the results. In this way we should combine the technical and commercial advantages of the distilling and benzol industries with those of the Motor Manufacturers' and users' organisation and it would fall to the oil group to furnish the distributing and transport facilities while each of these interests contributed its quota to finance the concern. In this way (and with local subsidiary companies throughout the Empire) the motor fuel question could be solved. It may be objected that this would create a gigantic monopoly, but the operations (unlike those of the oil group) would be on British territory and the various Governments will certainly legislate if necessary to prevent abuses. In this connection it is significant that the Standing Committee of the Board of Trade on the Investigation of Prices, reported in March, 1920:—

"The only ultimate solution of the motor fuel problem is the production of home and,/or Empire-produced power alcohol.

"We are also of opinion that, unless "steps are taken by the Government to "control the production of power alcohol, "any marked development in its production "would, under present circumstances, "result in a similar monopoly to that which "now exists in the case of petrol. We "think, therefore, that steps should be "taken to ensure that the production and "distribution of alcohol should be under "Government control."

We come now to the second and third headings, *Denaturation and Excise Restrictions.* These might possibly be dealt with more or less side by side, as Denaturation is, in effect, a Customs and Excise restriction designed (as all such are) for Revenue protection purposes.

Denaturation, or the rendering unpotable, of alcohol is a subject of considerable difficulty and for this reason: The Revenue authorities rightly insist on the use of denaturants which shall effectively and *permanently* render alcohol unfit for human

consumption. Unless this has been done industrial alcohol pays the potable spirit duties—which means a full stop to its production and development. The desiderata for a denaturant have been recently defined by the Board of Customs and Excise, London, as follows :—

1. The material must be soluble in alcohol, benzol and petrol, and in certain mixtures of these.
2. The material should not be capable of ready separation from its solutions in the above liquids and mixtures, for instance, by distillation, filtration, precipitation or dilution, with an excess of any one of its primary constitutents, or with water, etc.
3. The material should be stable on keeping, and should be unaffected by contact with metals. These considerations indicate the desirability of excluding certain substances which might otherwise be suitable, *e.g.*, halogen compounds.
4. The material should be such that small traces of it could be detected readily by chemical test.
5. The material should be cheap and plentiful.
6. The material, in alcoholic solution, should have a nauseous taste and possibly smell.
7. The material should not be highly poisonous.
8. The products of combustion of the material should not have marked action on metals.

It is found in practice that no one simple substance fulfils these requirements, but that the difficulty is got over by using substances which are themselves either of complex character or are a mixture of different substances, which complementarily fulfil the requirements. In this country a mixture of wood naphtha with mineral naphtha has hitherto been employed for the purpose. Its chief recommendation is that from the Revenue point of view it is very convenient as very small amounts can be detected by analysis (thus facilitating convictions), and because its removal from spirit is exceedingly costly and difficult. But it is well recognised that, as a means of rendering the alcohol undrinkable, it is of comparatively little use. Alcohol so denatured is readily masked by admixture with tea, beer or other suitable substances (as was pointed out to Lord Playfair's Committee on Alcohol in 1891). It is quite unsuitable for use in such countries as India, and here may be quoted the recently issued Report of the Government of India's Industrial Alcohol Committee of 1920: "In the words of Sir Charles Bedford which, though written in 1906 when the present denaturants were proposed for adoption, appear equally applicable to-day, methylated spirit constitutes a less offensive beverage than certain country liquors being at present sold throughout India," and can be rendered potable by admixture with mahua spirit. For this reason they endorsed my previous recommendation (which was adopted by the Government of India) that methylated spirit should not be recognised as denatured spirit in India. There is another serious count against methylation of alcohol. Not only does it make the spirit dangerously poisonous (and to kill or permanently blind a person who drinks such spirit is surely an excessive penalty for drinking it) but the price of methyl alcohol has lately risen so much as to make its use undesirable as a denaturant. The same remark applies to pyridine, which has within the last year risen to over £1 a gallon, and which was proposed recently by the British Government for use along with methyl alcohol for retail spirit denaturation. We must therefore look round for other denaturants in substitution for those now in use, and in this and in many other countries which have merely imitated the methods used here.

The initiative in such matters is scarcely to be looked for from the English Government Departments concerned, though this is not the case in India, where the Government of India in 1905 directed me (when I was Director of their Central Excise Laboratory) to enquire into the subject. The result was the recommendation of light caoutchoucine and crude mineral pyridine bases, ½% of each. Concerning this, the 1920 expert Government of India Committee report:—"We are of opinion that the only denaturants which are satisfactory for Indian purposes are pyridine and light caoutchoucine. The reasons for their adoption were fully considered in 1906, and, as they have stood the test of more than ten years' employment, it is unnecessary to enter on a defence of them here. . . . We consider that the ordinary denatured spirit at present in use in India is satis-

factory, and there is therefore no necessity to change its specification.''

In 1906 I had previously reported to the Government of India that *redistilled* bone oil in $\frac{1}{8}\%$ was a specially suitable denaturant, and further drew attention to the added deterrent effect, in the case of Hindus and Mohammedans, of drinking spirit containing dead animal (possible pig) matter. In fear of political objections (however baseless and fanciful) the Government of India preferred my later proposed denaturants as both these were of mineral origin. As regards suitability for use in motor engines, light caoutchoucine and pyridine could not at the time be effectively tested, and so my report was emphatic in excluding them from motor use pending trials as to suitability for such purposes.

The Denaturation Sub-Committee of the Empire Motor Fuels Committee has been conducting an exhaustive practical enquiry into the whole subject of denaturation (and has by press notices invited the public's assistance by suggestions) and in their last report submitted by Sir George Ashdown, K.B.E. (who has kindly acted as Chairman during my absence in India) it is stated that:

''As the result of a considerable amount of work, it was decided that redistilled bone oil was the substance which most closely complied with the desiderata for a denaturant as laid down by the Board of Customs and Excise.'' At the present time, the Engineering Sub-Committee of the same body are understood to be conducting elaborate enquiries on a large working scale, and in conjunction with the experts of the London General Omnibus Company, and their report is now awaited. Light caoutchoucine in combination with secondary substances such as shale oils, benzol, petrols, sulphurous oil residues comes next in efficacy but, as already mentioned, it is not known yet if it would serve for motor use. It will thus be seen that active practical work is being carried on to obtain and test new and improved denaturants, and at the same time the various Empire Governments are being kept in close touch with the work in question. Indeed, my Sub-Committee initiated their work by a Conference with representatives from the various Empire Governments.

It is the aim of the Committee to bring about a simplification and cheapening of denaturation methods throughout the British Empire, and, if at all possible, to procure the use of similar denaturants throughout the Empire so as to promote ease and despatch in denaturation operations. At present the position is that denatured spirit from, say, India, is refused admission to England (though much more efficiently denatured than the English spirit) because it is not denatured with the English denaturants. It would either have to be returned to the country of origin or be re-denatured here with the English denaturants, thus greatly adding to its cost and depreciating its quality by excessive denaturation. The difficulty of obtaining common methods of denaturation throughout the Empire chiefly hinges on the need of the Revenue officials (on importation of the spirit) to make sure that denaturants of equal quality and offensiveness to those used in their own territory have been employed when denaturing the alcohol overseas. This is an administrative detail which should be got over in due course, as there are adequate means of ensuring the quality of the denaturants by arrangements between the exporting and importing countries of the Empire.

The Customs and Excise Restrictions on the manufacture, storage, distribution and retailing of alcohol are far too numerous and complicated to admit of discussion here. The Government of India (in response to my direct representations in July, 1919, and later) appointed an Industrial Alcohol Committee (presided over by the Honourable Sir John Maynard) to whose report of 1920 reference has already been made.

The terms of reference were to consider and report as to the suitability and any requisite modifications of existing Excise regulations in India for the large scale production, sale, storage, and transport of industrial alcohol and also to consider whether the present denaturation regulations in India were suitable.

The resulting report contains a very important and useful set of findings which will be of considerable assistance to us in framing recommendations to the various Empire Governments on the subject. It will be realised that until such modifications have been made and given legislative and departmental effect, the position as regards the development of a large new alcohol industry is an impossible one on account of existing Revenue restrictions. No doubt much delay will be experienced before the negotiations are brought to a

practical issue with so heterogeneous a body of Governments as constitute what has been described as "that ramshackle edifice, the British Empire." On our part we can only undertake that wherever the delay may occur it will not be with either of our Sub-Committees. But it is, in a way, perhaps fortunate that large scale alcohol production is not an immediate practical issue, as we are not yet far enough advanced with our negotiations as to denaturation and Customs and Excise modifications with the various Governments concerned to deal with large supplies for the market. At the same time we have fully allowed for the inevitable delays and have initiated our proceedings and negotiations with the various Governments at the earliest moment possible, and we are now actively pressing them forward.

The last division of the subject is that dealing with the necessary *modifications of the internal combustion engine for use with mixed alcohol fuels and for pure alcohol later on.* It was my privilege to propose to the Empire Motor Fuels Committee the formation of a special Sub-Committee for this purpose which is now presided over by that well-known authority on such matters, Dr. W. R. Ormandy. It is understood that important practical work is being pushed forward by the Sub-Committee in close collaboration with the Engineers of the London General Omnibus Company, who have (originally at the request of Mr. Long's Inter-Departmental Committee on Power Alcohol) been conducting running trials with a fleet of their omnibuses for some time past. One cannot do better than refer those interested in this subject to the report by a member of the Empire Motor Fuels Committee, Mr. G. V. Shave, who is Chief Engineer of the London General Omnibus Company. The paper will be found at page 165 of the proceedings of the Imperial Motor Transport Conference of 1920. The Sub-Committee are systematically experimenting on the practical scale with alcohol alone and in admixture with benzol, petrol or other fuels in order chiefly to ascertain:—(*a*) The requisite modifications in engine design and construction for alcohol or mixtures; (*b*) The most suitable proportions in which alcohol mixtures should be employed; (*c*) The effect of various alcohol denaturants on the engine and the relative suitability of the denaturants tried.

The valuable work being carried out by Dr. Ormandy's Sub-Committee has been partly subsidised by generous grants from the Royal Automobile Club and by the Commercial Motor Users' Association, and more recently by a small annual Government grant. The expenses of such work are necessarily very heavy and it is to be hoped that this most useful and public spirited effort will not be hindered for lack of the essential sinews of war.

It will be seen from what has been said to-day, that, while the large scale production of alcohol is overwhelmingly the chief requirement, the Empire Motor Fuels Committee (all of whom it may be noted give their services in an entirely honorary capacity) are actively working to remove all obstacles (natural or artificial) to the full use of Power Alcohol when available in the market in cheap, adequate, and assured amounts.

The numerous *uses of Alcohol for the development of industries* in the United Kingdom and in our Overseas possessions, have also been receiving attention. In India, for example, one is prepared to indicate many remunerative outlets for Industrial Alcohol on a large scale. Many substances at present exported as raw materials could, if cheap and sufficient supplies of industrial alcohol were assured, be converted into finished products. In certain cases, raw materials which are mainly or even only obtainable in India and which at present are almost wholly exported (to the great benefit of the foreigner) could certainly be converted into finished materials in India itself, and with a correspondingly great financial advantage to the British and Indian industrialist and trader. The far-sighted industrialist and capitalist will not lose sight of this aspect of the subject, not only as affecting our vast Indian Empire, but in other parts of our Overseas possessions, and will not limit his view of the subject to the motor uses of alcohol only, however important and pressing these may be.

To quote in conclusion, the opinion on Industrial Alcohol of a joint select Committee of the U.S.A. Congress, given over 20 years ago and truer than ever to-day:—

"No article entering into manufacture "or the arts, whether of domestic or foreign "production, performs more legitimate or "beneficial functions. There is scarcely a "manufacturer in the country who does

"not use alcohol in the production of his "goods to a greater or less extent."

We may to-day add to this statement that in the development of production of denatured alcohol, we have the key to very many vast and most lucrative industrial and trade developments throughout our Empire.

DISCUSSION.

THE CHAIRMAN said the subject-matter of the paper had passed from the laboratory into the commercial world. He attributed that result to Sir Charles Bedford's having discarded the search for an economic foodstuff and having betaken himself to the investigation of waste vegetable materials. That, he gathered, was the foundation of the new enterprise. At the present day, one shuddered to think of the difficulties of finding finance even for the purchase of large quantities of waste vegetable materials, and he felt great relief, that the question of finance, usually most difficult, ought in the matter under discussion, to be solved by the co-operation of the oil companies, the distributing companies, and the transport companies. The appearance on the scene of that very wealthy corporation, the Burmah Oil Company, was a distinct augury of unselfishness and success. They were evidently taking the broad and not the narrow line, and if they could believe, as they evidently did believe, that the proper course for a great oil company operating in India was to back up a new Empire industry of this sort, he had very little doubt that those companies with which the Burmah Oil Company was closely associated, would follow on the same line. One word as to Government control. As an old permanent Secretary of the Board of Trade, and perhaps on that account, he was exceedingly distrustful of Government control in any shape or form. In saying that he quite recognised that not long ago a department of State had been created, with which his friend Sir Frederic Nathan was connected, charged with the duty of helping the scientific inception of new industries, but not charged, as far as he was aware, with the duty of nursing them from their births to their graves. He was opposed to subsidies. He hoped Sir Frederic Nathan would not consider that, in making those observations with regard to subsidy, he was for a moment confusing subsidy with a grant for scientific assistance in the inception of a new industry. If the programme put before the Royal Society of Arts that afternoon could be, as he believed it would be, presented to the world in a business form, backed by money, by good names and with the assistance in its early days of the best men Government could supply, he had no doubt that the work to which Sir Charles Bedford had applied himself would mark the beginning of a new era in one of the most important businesses of the British Empire.

MR. E. S. SHRAPNELL-SMITH, C.B.E., F.C.S., M.Inst.T., dealing with the question of price, said speaking as a motorist and as the Chairman of more than one motoring organisation in this country, and particularly the commercial transport organisation, the motor fuels availabe to such organisations must be seen at much lower prices. At the moment very little hope was to be derived from the current price of industrial alcohol in this country, which, for wholesale lots of not less than 100 gallons, was no less than 6s. a gallon. They must look to the investigations upon which so many present were engaged to change that figure of 6s. to something certainly not in excess of 2s. 6d., and he believed that that figure was to be encompassed. The lower the price the greater the consumption. One turned to American statistics in regard to industrial alcohol over the last 10 or 15 years, and one was absolutely riveted by the fact that the upward curve of consumption in a ratio of about 6 to 1 in the last 10 years had coincided with a drop in the price at which the commodity was marketed; and he ventured to say that the distilling interests of this country, or any new interests that might identify themselves with the production of power alcohol, whether by new manufacture in this country or by importation, would be well advised, once they had their technical and scientific sides in order, to keep the price as low as they could, in order to encourage the consumption not only for motor purposes but as a solvent for many other purposes to which reference had been made by the author. Of course, there was the handicap of legislation. The Finance Bill contained two clauses, clauses 9 and 10, dealing with the question of relaxation in favour of "power methylated spirits," and he was sorry to see that in those two clauses, as they stood, whatever might happen to them between now and the Report Stage of the Bill, nothing was put forward on behalf of the Government to touch upon either the question of the removal of the residue of the import duty which now remained in force, or to improve the out-of-date restrictions enforced upon distillers in this country as regarded the manufacture of spirits from which power methylated spirits could be made. With regard to food-stuffs, the author was better informed on that subject than he himself was, but it did seem to him that there were certain food-stuffs of local value which, if the production were multiplied by two, nobody would be found to eat. He referred, for instance, to sago palm, cassava and even to molasses. There were large quantities of molasses in the world now which were not turned to account even for cattle-feeding, and those must be brought into line for the benefit of power alcohol production as long as the requirements for human feeding

were first met. On the use of alcohol as a supplementary fuel, he agreed with the author that at present, whatever the future might have in store, power alcohol would tend to come on to the market in this country in relief of the unfortunate motorists as a mixed fuel, and he looked to the sale of alcohol mixed with benzol or with petrol of certain characteristics rather than its sale purely as alcohol. That caused him to mention, in passing, that he could not quite understand why, in the paper, the author had not made even a passing reference to the extensive use in South Africa and Australia and other countries of etherised alcohol under the name of Natalite. As to finance, and the co-operation of the various interests, motorists looked rather askance at anything in which the oil companies were supposed to have their fingers. They might be wrong. It might be that the benevolent entry of one oil company would give a good lead to the others, and there was much to be said, complex though the situation was, for co-operation between those interests. because any body of motorists or any group of financiers, in attempting to get together in order to put the huge problem of a new fuel production on a commercial basis, had better recognise at the outset that they were up against a matter requiring very many millions of pounds, unless they had the advantage in transit matters and distribution matters of some assistance from those great interests, which very often were abused when the services which they rendered were not thoroughly understood. It was very easy to criticise, and it was very hard to understand, all the circumstances of those interests about which one was only incompletely informed. The department of Scientific and Industrial Research was helping the Empire Motor Fuels Committee, and he desired to take the opportunity of acknowledging how valuable its services had been. With regard to the author's reference to rice straw, the progress which Sir Charles Bedford had made in Burma was remarkably encouraging. The weights of rice straw within reasonable distance of Rangoon rather enabled one to envisage large shipments of power alcohol within the next few years. In that connection he would like to ask Sir Charles's personal opinion as to the bearing of the "Yellow Peril" upon that new enterprise. What about China? If Burma could produce that large quantity of power alcohol, could not China be looked to to produce a great deal more, or were there physical or other difficulties in the way?

Sir Frederic L. Nathan, K.B.E. (Power Alcohol Investigation Officer, Fuel Research Board), remarked that the author referred in the paper to the question of further work in connection with the utilisation of the waste vegetable materials which were to be found within the Empire, and which were replaceable year by year without, in many cases, any attention or labour of any kind. That problem of the utilisation of those materials had been engaging the attention of the Scientific and Industrial Research Department. It was much too early to say yet what the eventual outcome of the researches would be. The subject was not a simple one, although it was simple up to a certain point, that was, if one could have for the purpose supplies of mineral acid. The author was very fortunate in that he had his raw material, his rice straw, where he had cheap labour, and had also available, no doubt, fairly cheap mineral acids. Those conditions did not apply throughout the Empire, and the researches upon which his (the speaker's) Department was at present engaged had for their object the discovery, if possible, of a process which should be independent, or independent to a very large extent, of the use of such acids. Whether success would be reached or not was a matter upon which he could not prophesy, but if success was reached on the lines on which his Department was working, he thought that the possibilities of using waste vegetable materials were immensely increased over the possibilities which the author had so successfully exploited. There was one other direction in which the activities of the Government had been working, a direction in regard to which there seemed to have been very considerable misapprehension, particularly in some of the technical papers recently, and that was the rather vexed question of excise restrictions. He did not propose to go into the controversial questions to which Mr. Shrapnell-Smith had referred, but he did wish to read the following extract from the *Times* of the previous day: "The Finance Bill for 1921 contains certain provisions in respect of power methylated spirits which are of considerable interest. These provisions were included in the Revenue Bill, and that measure having been dropped, they have now been incorporated in the Finance Bill. Section 9 provides that the Commissioners of Customs may make regulations governing the manufacture of any spirits in Great Britain and Ireland by other processes than the distillation of fermented liquor," and in that connection he would point out that the Government were really taking time very much by the forelock. They were already providing for giving themselves powers to make regulations in the event of synthetic alcohol becoming a commercial possibility. Section 10 gave the Commissioners very comprehensive powers to make regulations in regard to the manufacture, storage, removal, sale, use and supply of methylated spirit. The powers given were very wide, and until those powers, or the regulations made under those clauses in the Finance Bill, had been made public, he thought Mr. Shrapnell-Smith's strictures on the action of the Government were a little premature. Mr. Shrapnell-Smith did not know what those regulations would cover. He thought that when they appeared, not only

Mr. Shrapnell-Smith, but the general public, would be satisfied that the Government had really taken the matter in hand and had dealt with it very comprehensively. He was not prepared to enter into what he might call the ethics of the production of alcohol of which the author had treated. It was to be hoped that alcohol would be produced, and if it was to be produced, it could only be by some body or corporation or company which had practically unlimited financial resources. When it was produced it would be in such quantities that it would add materially to the liquid fuel requirements of the world. When that time arrived, that was to say, when the supply of liquid fuel was in excess of the demand, a material reduction in the price of liquid fuel could certainly be looked to.

Dr. W. R. Ormandy, F.I.C., F.C.S., said it was about 20 years since he had first lectured before the Royal Automobile Club, pointing out that it was time that they began to take steps to pave the way towards the production of some alternative fuel to petrol, as at that time petrol had gone up in price from 9d. to 11d., and everybody was feeling very disgusted. It was quite obvious that the direction in which he had wished to go was correct, and the fact that the same subject was still being discussed showed that it was right and proper; but he had been a little previous, as had been the author. Nevertheless seven or eight years later it was interesting to note that just as to-day Sir Charles was looking for help from the Burmah Oil Company, so at that time the community at large got help in the direction of the development of the whole problem of the utilisation of alcohol from one who had been very closely and intimately connected with the oil industry, because it had been Sir Boverton Redwood who had done more than anyone to push the fact down the throats of the public at all times, that the problem of industrial alcohol, particularly for power purposes, must be followed up; and it seemed that history was repeating itself, and that the oil industry was helping the alcohol, or prospective alcohol, industry. The author stated that waste products ought to be made use of. That, of course, was perfectly obvious; but the point he (Dr. Ormandy) wished to raise was that 20 odd years ago a gentleman named Classen, a very celebrated chemist, had pointed out that cellulose could be converted into sugar which could be fermented. He (the speaker), had gone so far as to state at a lecture at the R.A.C. that the solution of their difficulties was immediately before them, and that Classen's process was going to solve the trouble of converting waste timber, straw, and cellulose into valuable and useful alcohol. Classen's process would do it, and had done it. During the war, in America, very large quantities of alcohol had been made from sawdust, but the point was it did not pay to do it. It was not sufficient that a process should work: it was necessary that it should pay at the same time. Until there was sufficient evidence that the troubles with which the Classen process met in the early stages had been overcome, those who advocated the possibility of the production of alcohol from molasses and food products should be given a hearing. If paper was to be made from straw, and alcohol from the residue, the position was the same with reference to motor fuel as it was in the case of benzol. Benzol was to all intents and purposes a by-product from the manufacture of hard coke, required in the manufacture of iron and steel, and there was just so much benzol produced as there was hard coke produced, or they were in that proportion. Our fuel supply, therefore, was practically a by-product of another industry, and one that would require very large capital in itself. The author had spoken about the desirability of getting co-operation from all the various factors interested in the problem of a cheap motor fuel, in order to find the necessary capital for experimental work, which might be directed to researches of waste cellulose materials. He agreed that that was a problem that ought to be tackled, but there was another problem which offered at least an equal chance of an early return, and that was the synthetic direct production of alcohol from water-gas and producer gas by means of catalysis. He had every reason to think that that was a problem which would solve the difficulty eventually. Then cellulosic material would certainly be required, but only to make charcoal from which water-gas would be produced. Those present who were scientists and who had watched the technical press would have seen that many patents had been taken out and that much research work was being done on that subject. He had seen himself ordinary water-gas such as was used in many industries, a cheap product made from coke and steam, converted to the extent of 90 per cent. into methyl alcohol of 99.2 per cent. purity. That was a step in the right direction, and eventually ethyl alcohol would, he thought, be made. But it did not alter the fact that what was required was an amalgamation of interests to find the necessary money, spent under real and proper scientific control, because it was by scientific development of that type that the great German industries were built up, and although in the past we had muddled through in our heavy industries, the time had gone when we could continue to muddle through. The world of the future was going to belong to those who used applied science properly, and the Government of this country had got to recognise that. Mr. Shrapnell-Smith had rather chided the author for not having referred to the production of Natalite in South Africa. He (the speaker) did not think there was any necessity

for the author to have referred to any particular article, as the producers were quite capable of bringing their productions to the notice of the public; but he might point out that in Natal and South Africa generally, they were importing some 6 millions gallons of petrol per annum, and were exporting a large amount of alcohol per annum. If Natalite was an absolute success, why did not they convert their home-grown alcohol into Natalite on the spot and reduce the amount of imported petrol? He had no brief against Natalite or any other mixture of alcohol in conjunction with ether, benzol, petrol or anything else, except that he had taken the standpoint publicly that he did not believe it was for the benefit of the industry at large and the public in general that mixtures of well-known products such as alcohol, benzol, petrol, acetone and ether (which all knew would form a perfectly good motor fuel if used under the right compression and so on) should be held as patents. He did not blame the people who took out the patents, but he blamed the Government for granting patents. The Patent Office gave patents for anything, and it was unfortunate that the public as a whole had to pay the fees. Either they had to pay the royalty that was demanded for the article, or somebody had to spend a lot of money in fighting a case at law in order to prove that what the Government gave them at considerable expense was not worth the paper it was written on. He had begun to think that the Patent Office had been subsidised by the lawyers!

Mr. Ben H. Morgan, after speaking of possible Empire Supplies of alcohol, said he thought he ought to mention that in addition to being Chairman of the British Empire Producers' Organisation, which was very interested in the production of power alcohol, he was also Chairman of the Alcohol Fuel Corporation, who were the owners of the Natalite patents which in common with others had come under the strictures of Dr. Ormandy. He thought Dr. Ormandy was rather unfair in classifying Natalite as one of those compounds for which a patent could be procured by the mere application at the Patent Office. Natalite was the product of an immense amount of experiment and expenditure, and it might interest the meeting to know something of its progress as a fuel in various parts of the world. Natalite would be on sale in this country to-day if it were not for the excise and customs restrictions. Companies were being formed here who were prepared to import alcohol, who had the sources of alcohol available, and who were prepared to set up factories for the conversion of part of it into ether and providing the necessary mixing and storage accommodation. That had all been settled, and they were only awaiting the removal of the restrictions which existed. The plant in Natal had been doubled within the last 12 months. Dr. Ormandy had referred to the fact that South Africa was still exporting alcohol. That was true, but a development of the kind about which he was speaking, took a very long time to eventuate. Every business man would appreciate the fact that it took time to establish a new industry in any country. He would venture to predict that in the course of ten years from to-day, there would be very little, if any, petrol sold in this country, as Natalite, as the most successful mixture that could be evolved from an alcohol basis, was infinitely superior to petrol for both motor work, aviation work and motor boat work. There was arriving in this country during the present week an experimental consignment of 500 gallons, with which tests were to be made by the leading authorities in this country, and the results of those tests would be published in due course. Mr. Morgan further referred to Natalite Companies trading in India, East Africa and Australia.

Dr. F. Mollwo Perkin, C.B.E., F.I.C., F.C.S., said the question to his mind, and to the minds of most people, he thought, was that the future of the British Empire depended upon liquid fuel. Whether liquid fuel was to be alcohol, or whether it was to be fuel in the form of petrol and other forms of hydro-carbons was what had to be found out. There were enormous quantities of coal in this country, and the question arose whether the fermentation process described by the author would pay in this country. Although it might pay in the Empire generally—in India, Africa, Egypt, and so on—probably in Great Britain and Ireland it would be found that the liquid fuel required would be better obtained from other sources. Ethyl alcohol could be obtained from the gases produced from coke ovens, and tests had been carried out which had given very satisfactory results. Alcohol could be produced from gases obtained from low temperature carbonisation, which at the present moment was in its infancy. There was a large amount of ethylene in those gases, and that ethylene could be converted into ethyl alcohol. Dr. Ormandy had referred to methyl alcohol obtained from water-gas; he thought he meant ethyl alcohol. Everyone had noticed that during the last few weeks the atmosphere of London and of other large towns had been very much better than it used to be. That was because much more gas was being used, owing to the coal strike, or, if not gas, fuel which did not give off smoke. By carbonising all our coal, alcohol might be obtained as a fuel from it, and also heavy fuel oils and light fuel oils might be got from it. The whole of the country then might be run on fuel oil or smokeless fuel. In the past we had exported our coal, and that export had brought us back other material. If we were going to obtain all our fuel oil or all our liquid fuel from abroad, what were we going to do with our coal? Where was the Exchange going to

be? If we could not export our coal, how were we going to keep the financial balance of the country? We were now importing largely fuel oil. If all that fuel oil had to come from abroad, and we were exporting nothing, where was the financial balance? We could make our own fuel oil; we could make our own alcohol, and then the balance of trade would not be against us. After the coal had been carbonised with production of oils and if necessary alcohol from the gases the coal residue should be briquetted, and those briquettes could be sent abroad. He believed that by such a process, one ton of coal would go as far as two tons to-day. He believed the alcohol production was more largely valuable in India, Egypt, and Africa than it would be in this country by the fermentation process. Possibly later on the fermentation process would pay in this country, but he thought the raw products were so large in other British possessions that probably the best outlook was in those places.

The Chairman then proposed a vote of thanks to Sir Charles Bedford for his valuable paper.

Mr. D. T. Chadwick, Indian Trade Commissioner, in seconding the motion, said that power alcohol was of the utmost importance to India. All the information on the subject that could be gathered in this country, would be very eagerly devoured in India; hence, both this paper and the discussion would be read there with the greatest interest.

The resolution was carried unanimously.

Sir Charles Bedford, in reply, said, in regard to one of Mr. Shrapnell-Smith's observations that the Yellow Peril had hung over us for so many years with not any very appreciable result, that he believed all present would be able to pass through their alloted span of life without seeing anything very terrifying materialise in that direction. The fact was that large countries like China and India were exceedingly slow to grow up; it was very difficult indeed to organise and produce through native sources, and it was very hard to get (especially new) industrial enterprises forward. Therefore, he did not regard the Yellow Peril with much apprehension. As to Sir Frederic Nathan's observation with regard to the amount of acid required, very small amounts were needed in the process; in fact, mere traces. With regard to the other possibilities of making alcohol from waste materials without the use of acid, they were keeping a very close watch on that, especially the manufacture of alcohol by the aid of certain micro-organisms; but that was in a stage at the present time which was very far from commercial realisation. With reference to Dr. Ormandy's remarks about the Classen process, that method dealt with a very difficult substance, namely, wood highly lignified. Many of the points of the Classen method had been considered in the process under discussion; for instance, it had been found that sulphurous acid, which Classen had used, was fibre wrapped round with the substance called lignin in the case of wood, and was very much more difficult to get at, whereas in the case of straw, the fibre-cellulose was considerably more easy to get at. Alcohol would not be a by-product, as Dr. Ormandy feared; it would be a main product. Paper and alcohol would be the two main products, and one would not be dependent on the other, because the commercial exploitation of them must go hand in hand. That was the essential difference between his and previous projects—he looked to paper production to help out alcohol manufacture from one and the same raw material. As to Dr. Perkin's remarks, the whole point was that for vegetable waste materials the manufacture must be on the spot; the material must be got as close to the factory as possible. Therefore, the idea of bringing such bulky raw materials over to this country was absolutely out of the question, because of freight conditions. With respect to carbonisation, etc. processes, those were in their infancy. When they were proved capable of fulfilling practical requirements, then no doubt they would be very important sources. As to coal exportation, it would be a long time before coal was supplanted as a means of heavy, long-distance haulage, and for such things as iron smelting, and so on. The point was a very long way off at which alcohol was going to drive a rail engine or smelt iron ore, so that coal would continue to have a very large field of its own, and more and more coal would be gasified and more economically utilised as intelligence spread regarding its proper use.

OBITUARY.

Sir R. Rowand Anderson, LL.D., F.R.S.E.—Sir Robert Rowand Anderson, who died at Edinburgh on the 1st inst., at the age of 87, had been a member of the Royal Society of Arts since 1903.

Born at Forres in 1832, he was educated in Edinburgh. Up to 1875, his practice was mainly connected with school and church architecture. His first great work was the Edinburgh Medical Schools, and this was soon followed by the Caledonian Railway Offices in Glasgow; Mount Stuart, Lord Bute's mansion in Bute; the Conservative Club, Edinburgh; the fine dome of Edinburgh University (completing Robert Adam's main façade); and the National Portrait Gallery, Edinburgh.

Another series of works was his restorations of Dunblane Cathedral, and the abbeys of Paisley, Culross, and Dunfermline, and the manner in which he carried out these tasks greatly increased his reputation as an ecclesiastical architect.

In 1887 he was invited, with other selected architects, to submit designs for the Imperial Institute, and in 1901 for the Victoria Memorial. He was also among the seven architects asked by the Royal Institute of British Architects in 1904 to submit designs for the extension of the British Museum. He received the honour of a knighthood at the Coronation in 1902, and in 1916, on the recommendation of the Royal Institute of British Architects, the King conferred on him the Royal Gold Medal for the promotion of architecture.

CORRESPONDENCE.

THE BRITISH RESEARCH ASSOCIATION FOR THE WOOLLEN AND WORSTED INDUSTRIES.

Referring to Sir James P. Hinchliffe's paper on the above subject in the *Journal* of May 27th, permit me to draw attention to an important point raised at the January meeting of the Bury and District Chamber of Commerce, by a member in the Hat Manufacturing Industry, regarding the pernicious effect of the substances now used for marking sheep. At a subsequent meeting the following resolution was passed—"In view of the great loss and expense incurred by all manufacturers of woollen goods owing to the presence of tar, pitch, paint, etc., in the raw wool, and also the amount of faulty manufactured goods resulting from the same cause, this Chamber urges the Council of the Associated Chambers of Commerce to take such steps as they consider best to impress upon all wool growers, at home and abroad,

(a) the necessity of discontinuing the use of such deleterious materials in the marking of sheep;

(b) the great benefit that would thereby result to themselves in the increased value of the wool if guaranteed free from such matter;

(c) and the great saving to all manufacturers of woollen goods."

Samples of the material in various stages of manufacture were exhibited at the Chamber, the Manufacturer stating that freedom from such matters would raise the value of the wool several pence per pound.

Directly after the first mention of the subject, I set about investigating it and am pleased to say that I have produced a composition which has fulfilled all the conditions of resistance to exposure to weather, on wool, and complete removal by the scouring process, without injury to the wool, when conducted on the laboratory scale. I am now arranging trials on a Scottish sheep farm and in a local hat factory, after which I purpose producing the preparation on the manufacturing scale.

J. MELROSE ARNOT.

CULTIVATION OF SAFFRON IN MACEDONIA

The plant (*Crocus sativus*) that produces saffron is an autumnal crocus, so named to distinguish it from its near ally, the spring crocus (*Crocus vernus*), which it closely resembles. It is a native of southern Europe, western Asia, and is extensively cultivated in Spain, France, Italy, and Cashmere. The product derived from this plant, saffron, is the dried orange-coloured stigmas; it requires about 4,000 of these to make an ounce. The product is used in various ways—as a medicine, in the manufacture of cordials and liquors; as a colouring matter; and in parts of Europe as a flavouring and colouring ingredient in cooking.

In planting, the bulbs are set in the ground about 10 inches apart and after six or seven years are taken up and separated, each original bulb yielding a new bulb for every year since planting. A feature of the growing of saffron is the possibility of using the same field for an early crop of some cereal which does not require deep planting. For a good harvest of saffron it is necessary that the weather be dry.

The root of the plant resembles an onion and is set in the ground in September and October about 7 inches below the surface. The plant springs from the ground one day and the next morning at sunrise there opens a flower of four and sometimes five petals and five to ten pistils, part red and part yellow. Each onionlike bulb gives every second or third day one flower and from 10 to 20 flowers each season, *i.e.*, from the latter part of September to the end of October. In the early morning of the day plants bloom the harvesting of the crop begins.

Women and girls are employed to do the harvesting; they go into the fields as soon as the blooms open and cut the entire flower from the stalk. The work is all done by hand. The flowers are then taken in baskets by the workers and spread on fibrous carpets, made for this purpose, with a coarse surface, left to dry for a day, and then "fanned." This fanning operation separates the dry petals from the flower, leaving the pistils caught in the fibre of the carpets. The pistils caught are left to dry for another five or six hours and then collected and the red separated from the yellow. The red pistils are utilised in producing a red dye. In this operation it is possible for a worker to separate up to one oke (2.82 pounds) a day. According to a report by the U.S. Vice-Consul at Salonica, the three villages, Goblitza, Vanitza, and Spourta, in the district of Cozani (Macedonia), at one time produced a crop estimated at 1,500 okes; but cereal planting has been more

profitable lately, consequently the crop is now only from 600 to 800 okes per year, a reduction of about 50 per cent.

After the harvest the saffron is packed in a crude state in matting trunks containing about 50 kilos (1 kilo—2.2046 pounds) each and hauled by donkeys or ox teams to Verria, a town of about 20,000 inhabitants. There the trunks are loaded into goods waggons and carried to Salonica, 31 miles away. On arriving at Salonica the trunks are unpacked, and the saffron is put through a process of refining which removes sand and other foreign substances by sifting. The product is then ready for the market. It is packed in tins and these tins in turn in wooden cases, holding 20 to 25 kilos; sometimes cases of 50 kilos weight are shipped.

The saffron crop from the Salonica district is sent mostly to France. Some finds its way to England. Little is sent to the United States, which is supplied from Spain. The cultivators predict, adds the U.S. Vice-Consul, that in a few years their plant will be more highly valued than at present as a result of the improved methods now being introduced.

THE CRISIS IN THE TEA INDUSTRY.

An authoritative article on the production of tea in the Empire and its relation to the tea trade of the world is contained in the current number of the Bulletin of the Imperial Institute. It deals in an interesting way with the growth of tea drinking in various parts of the world, gives particulars of the industry in all tea producing countries, and discusses the causes which have led to the present serious crisis in the industry.

India and Ceylon together produce more than two-thirds of all the tea which enters into the world's commerce, their most serious competitor at the present time being Java. At the beginning of 1919 prices in London for all grades of tea were good, and stocks in the United Kingdom were not excessive, but apparently no account was taken of stocks held in producing countries. The tea trade had been disorganised by the War, and by Government control, and as no danger signals, pointing to over-production, were raised, the plantations in the British and Dutch Indies in 1919 produced tea to their full capacity. The Russian market, which had been taking nearly 100,000,000 lb. of plantation tea yearly, was lost and stocks began to accumulate, until, in the middle of last year, the actual situation was realised and there was a break in prices for all the lower grades, which have since been selling below the economic value. There is no question regarding the soundness and ultimate prosperity of the tea industries of India and Ceylon, but the immediate outlook for many estates is very critical. The seriousness of the position is apparent from the fact that the plantation industry in the two countries supports at least 3,000,000 workers and their dependents.

It is thus to the common interest of both producer and consumer that the tea industry should be placed on a sound basis. The most serious obstacle, however, to the return of more healthy trade conditions is the great accumulation of stocks of common teas. In the absence of a demand from Russia there appears to be little prospect, in the immediate future, of reducing the volume of these stocks, but unless this is effected, or the sales of tea regulated, there can be no recovery in prices for a long time.

GENERAL NOTE.

VICTORIA AND ALBERT MUSEUM.—A selection of printed and painted cottons, lent by Mr. G. P. Baker, is now on exhibition in the Loan Court of the Victoria and Albert Museum. A fine selection of these was shown at the Royal Society of Arts in 1916, when Mr. Baker read a paper on them; and he has since written an important work on the subject, "Calico Painting and Printing in the East Indies in the XVIIth and XVIIIth Centuries," which was reviewed in the *Journal* of May 20th.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

TUESDAY, JUNE 14.. Sociological Society, at the Royal Society, Burlington House, W., 8.15 p.m. Hon. V. S. Srinivasa Sastri, "The Non-Co-operation Movement in India."

Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Dr. R. P. Blake, "Sources of the History of Georgian Ecclesiastical Literature."

WEDNESDAY, JUNE 15.. University of London, South Kensington, S.W., 5.15 p.m. Dr. A. D. Waller and Mr. J. C. Waller, "Experimental Studies in Vegetable Physiology and Vegetable Electricity." (Lecture V.)

Oriental Studies School of, Finsbury Circus, E.C., 12 o'clock. Miss A. Werner, "European Expansion in Africa." (Lecture VIII.) (Uganda.)

Municipal and County Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W. Annual General Meeting. Presidential Address and Conference on Housing and Town Planning.

Meteorological Society, 70, Victoria Street, S.W., 5 p.m. 1. Mr. G. M. B. Dobson, "Causes of Errors in Forecasting Pressure Gradients and Winds." 2. Mr. R. F. Granger, "The Physical Structure of Cloud-Form in the Lower Atmosphere." 3. Messrs. N. A. Comissopulos and J. Wadsworth, "Variability of Temperature over North America and Europe during the ten years, 1900-1909."

THURSDAY, JUNE 16.. Municipal and County Engineers, Institution of, at the Institution of Civil Engineers, Great George Street, S.W. Address by Sir Henry Maybury. Conference on Roads, Sewage Disposal and Public Works.

Oriental Studies, School of, Finsbury Circus, E.C., 5 p.m. Mr. W. M. McGovern, "The Buddhist Literature of China." (Lecture V.)

FRIDAY, JUNE 17.. Royal Institution, Albemarle Street, W., 9 p.m. Sir J. J. Thomson, "Chemical Combination and the Structure of the Molecule."

Journal of the Royal Society of Arts.

No. 3,578. VOL. LXIX.

FRIDAY, JUNE 17, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One hundred-and-Sixty Seventh Annual General Meeting, for the purpose of receiving the Council's Report and the Financial Statement for 1920, and also for the election of Officers and new Fellows, will be held, in accordance with the By-laws, on Wednesday, June 29th, at 4 p.m.

At the Annual General Meeting the Council will propose the following resolution :—

That By-law No. 47, relating to the date of the opening of the session, be altered and amended by the substitution of the word "first" for the word "third."

The By-law, as amended, will read as follows :—

By-law 47.—"The Session shall commence on the first Wednesday in November, and shall end on the last Wednesday in June."

(By order of the Council)

GEORGE KENNETH MENZIES,

Secretary.

SOCIETY'S ALBERT MEDAL.

The Albert Medal of the Society for the current year has been awarded by the Council, with the approval of His Royal Highness the President, to Professor John Ambrose Fleming, M.A., D.Sc., F.R.S., in recognition of his many valuable contributions to electrical science and its applications, and specially of his original invention of the thermionic valve, now so largely employed in wireless telegraphy and for other purposes.

INDIAN SECTION.

FRIDAY, JUNE 10th, 1921; Sir W. D. Sheppard, K.C.I.E., Member of the Council of the Secretary of State for India, and formerly Member of the Bombay Government, in the Chair. A paper on "The Development of Bombay" was read by Sir George Curtis, K.C.S.I., Member of the Executive Council, Bombay, 1916-21.

The paper and discussion will be published in a subsequent number of the *Journal.*

THE ROYAL SOCIETY OF ARTS.

TWENTY-FIRST ORDINARY MEETING.

WEDNESDAY, MAY 11TH, 1921.

MR. GEORGE E. MACLEAN, Ph.D., LL.D., Director of the British Division of the American University Union in Europe, in the Chair.

THE CHAIRMAN, in introducing Mr. Hayes, the author of the paper to be read, said his name was known to most of those present as that of an original man; he had not taken a University degree, but he was what was especially admired in the United States, *i.e.*, a self-made scholar. Amongst the Americans, Mr. Edison was not a College-bred man, but what was the debt of the world to Edison? It was a privilege to one who had had the great opportunities that had come to him personally as an academic man to introduce a man who had made his own way with his own weapons and who was known as an authority on the English language and as a friend of the English-speaking Union. Mr. Hayes stood for something even larger than the English-speaking Union, whose object was to tighten the bonds of comradeship between English-speaking peoples, for he included all peoples in his quest, in order that, through the weapon of the English language, the day might be hastened when the people of the world would escape from the ill effects of the Tower of Babel and would be universally able to understand and read, if not speak, the famous English tongue.

The following paper was then read:—

PHONOSCRIPT:

A new method in the Phonetic Teaching of English Pronunciation.

By Alfred E. Hayes,

General Secretary of the English Language Union.

The presence of our very young friends and the necessity of getting them home to bed as early as possible, compels me to ask you to permit me to depart from the logical order of this demonstration. At an earlier hour of the day I should have preferred to state the case for Phonoscript first, and to give the demonstration in proof afterwards. Under the circumstances this order must be reversed, but before I proceed to call in the aid of the children I ought to state briefly, for the especial benefit of the practical teachers present, the precise conditions under which they have been taught.

Holy Trinity School has but three Infant Classes. This means that fine grading of natural capacity is impossible. In schools in which there are two or more classes of the same grade (or standard), the work would be much easier and more effective. Eleven of the children here have been under instruction in Phonoscript for three months, three weeks of which were practically lost owing to the illness of the teacher. Of these eleven, two are just seven years of age, the rest are five or six. The three remaining children entered school for the first time at the beginning of April. Of these three, two are four years of age and one is five. No attempt was made to teach them anything for some days. They have had lessons in Phonoscript for fourteen school days only. In that period they had learnt to give correctly, as you will presently discover, the sounds of the 47 characters shown on the chart exhibited.

There is a Reading Lesson every morning and afternoon of twenty minutes duration each. No *new* work is done in the afternoons. New work is taken on four mornings in the week. The afternoons and both lessons on Fridays are given up to recapitulation work only.

No charts or books have been available. All the lessons have had to be written on and taught from the blackboard only. The three teachers who have carried out the experiment came to it with no special phonetic training, and one of them was of Senior School experience, and had never taught Infants before. It will, therefore, be readily understood that the experiment has been carried out under conditions rather less favourable than those commonly attainable.

[*The demonstration by the Children then followed. The three youngest first sounded correctly the 47 characters learnt by them in 14 days. A paragraph chosen by a member of the audience from an educational work in her possession was then copied on the blackboard in Phonoscript and read by all the children without difficulty. The audience was then asked to send up in writing specially difficult word tests, e.g., "Publicity," "Hebblethwaite." Mr. Hayes added to these some of the common class-room 'bug-bears,' such as "bough," "bought," "cough," "teacher," "leather," etc. All these examples were correctly read.*

To show the elasticity and adaptability of Phonoscript, the lecturer wrote up sentences in ordinary spelling which, when read by the children, proved to be examples of the speech of Edinburgh and 'Cockney' London. This closed the actual demonstration.]

The problem presented by the want of correspondence between symbol and sound in written or printed English is one which has confronted every teacher and student of the language for many centuries, and numerous attempts have been made by both scholars and cranks to find a satisfactory solution. This want of harmony between sign and sound hinders more than anything else the study and use of English as a world-speech, and throws upon the children in our schools and upon their teachers an intolerable burden. The problem as it faces the foreign student has been clearly stated by Professor Craigie, of Oxford University, in the introduction of his little book "*The Pronunciation of English.*" He says, "The difficulty of inferring the pronunciation of English words from their written form, is mainly due to the frequency with which the same symbols are used to represent different sounds, and to the uncertain position of the stress in words of two or more syllables. To become familiar with the pronunciation of the language as a whole the foreign student must either receive prolonged instruction from a teacher, or must make extensive use of phonetic aranscriptions and pronouncing dictiontries. With either or both of these methods the correct reading of English in the ordinary

spelling must, from the outset, be largely a matter of memory.''

This is bad enough for the foreign student, and fifteen years' experience as Director of the Danish State's Summer Holiday Courses for Teachers of English in the Danish Secondary Schools has made me acutely conscious of his need of more effective help; but it is as a Headmaster of a Primary School containing Infant Classes that I have been most painfully impressed with the imperative necessity for some more readily acceptable solution of the problem than those so far presented. It is not merely that the process of teaching young children to read involves the expenditure of a large amount of time, energy and patience. To me the most disastrous consequence of our chaotic orthography and our present methods of dealing with it is the immense mischief done to the natural growth of the child's powers of reasoning. Every child is continually making deductions from reiterated presentation of the same or similar impressions. His faith in this natural process, this embryo faculty of reason, is cut to the root by the constant contradictions and re-statements of the values of his letter-symbols. The same precisely identical character stands for one sound one day, for another the next, and so on through, in the cases of some of the vowels, more than a dozen contradictions. Not only is it never safe for him to infer the sound of a single letter, but he finds the sounds represented by combinations of letters equally confusing, as in such examples as ''plough,'' ''tough,'' ''device,'' ''police;'' ''now,'' ''know''; etc.—and in the converse instances of the same sound represented by different letters as in ''key,'' ''quay;'' ''been,'' ''bean''; etc.

I am convinced that these continual assaults upon the child's budding reason have far graver consequences than is generally appreciated, and that much of the muddled mental meandering that passes for adult thinking is traceable to this early destruction of faith in the validity of the natural logic of the normal mind.

In the British Museum one may find the records of more than seventy different solutions of our trouble, and during the past three years the letter-bag of the English Language Union has bulged with pamphlets and manuscripts of phonetic salvation from all corners of the earth. Quite recently at least three able and scholarly works have expressed their authors' want of faith in their predecessors, and their confidence in their own remedy. I am following in their distinguished train with a less ambitious but, I venture to hope, a more immediately practicable scheme. The demonstration you have just witnessed, and which you have so appreciatively received, does, at any rate, prove its feasibility.

The schemes advocated hitherto fall broadly into two classes:—

(*a*) Those completely phonetic, *i.e.*, those giving each sound one sign and each sign one sound only, thus necessitating a radical re-spelling of the language;

and

(*b*) those giving each sign one sound, but not each sound one sign, thus preserving the present spelling.

Falling partly into one or both of these classes are a few compromises. Of these the best known is that of the Simplified Spelling Society, which alters the usual spelling, employs digraphs to represent single sounds, gives in a few frequently-used words more than one sound to the same sign, and makes no provision for the important and constantly-occurring obscure neutral vowels.

To class (*a*) belong the alphabet of the International Phonetic Association, and Prof. Jespersen's modification of it, Pitman's Phonotype, Dr. Frank Vizetelly's scheme, the alphabets of the U.S.A. National Education Association's Joint Committee, Sir Harry Johnston, Dr. Wilfrid Perrett and many others.

To class (*b*) belong Miss A. Deane Butcher's Orthotype, the schemes of Professor Craigie, Professor John Clarke and many of the popular dictionaries, my own Phonoscript, etc.

Of a selection of these schemes the lantern will now give us a few illustrative examples, together with Phonoscript transcriptions for general comparison.

Pitman's 'Phonotype'.

đi tų frogz.

a taŋk in hwic tų frogz had loŋ livd woz draid up bai đi hįt, and đɛ wer at leŋŧ oblaijd tu sįk wɷter els-hwɛr. az đɛ wer jurneiŋ on đɛ rįct đi ej ov a dįp wel in hwic đɛ sɷ a gud dįl ov wɷter. "ʃal wį jump in hįr?", sed wun ov đi frogz; "it iz boŧ kųl and dįp and, laik aur yuʒiual dweliŋ-plɛs, đi soil iz damp and đɛr ɑr a fiu pɑm-trįz raund abaut; wį nįd go no fɑrđer," — "nɛ", sed đi uđer; but if đi wɷter ʃud fɛl hįr ɷlso, hau wud yu get aut agɛn?".

The same in 'Phonoscript'.

the two frogs.

a tank in which two frogs had long lived was dried up by the heat and they were at length obliged to seek water elsewhere. as they were journeying on they reached the edge of a deep well in which they saw a good deal of water. "shall we jump in here?" said one of the frogs, "it is both cool and deep, and like our usual dwelling-place, the soil is damp and there are a few palm-trees round about; we need go no farther." "nay," said the other, "but if the water should fail here also, how would you get out again?"

The International Phonetic Association's Transcript.

ðə nɔːɹθ wɪnd ənd ðə sʌn wɛɹ dis'pjuːtiŋ hwitʃ wəz ðə strɔŋgəɹ, hwɛn ə travləɹ keːm ə'lɔŋ rapt in ə wɔɹm kloːk. ðeː ə'griːd ðət ðə wʌn huː fəɹst meːd ðə travləɹ tek ɔf hiz kloːk ʃud bi kon-'sidəɹd strɔŋgəɹ ðən ði ʌðər. ðɛn ðə nɔːɹθ wind bluː wiθ ɔːl hiz mait, bʌt ðə mɔːɹ hiː bluː, ðə mɔːɹ kloːsli did ðə travləɹ foːld hiz kloːk ə'raund him; ənd ət last ðə nɔːɹθ wind geːv ʌp ði ə'tɛm(p)t. ðɛn ðə sʌn ʃɔn aut wɔːrmli, ənd i'miːdjətli ðə travləɹ tuk ɔf hiz kloːk; ənd soː ðə nɔːɹθ wind wəz ɔ'blaidʒd tu kon'fɛs ðət ðə sʌn wəz ðə strɔŋgəɹ əv ðə tuː.

The same in the Association's Script.

ðə nɔrθ wind ənd ðə sʌn wɛr dispjutiŋ
hwitʃ wəz ðə strɔŋgər hwen ə travlər kem əlɔŋ
rapt in ə wɔrm klok. ðe əgrid ðət ðə wʌn hu fərst
med ðə travlər tek ɔf hiz klok ʃud bi kənsidərd
strɔŋgər ðən ði'ʌðər. ðen ðə nɔrθ wind blu wiθ ɔl
hiz mait, bʌt ðə mɔr hi blu ðə mɔr klosli did ðə
travlər fold hiz klok əraund him; ənd ət last ðə nɔrθ
wind gev ʌp ði ətempt. ðen ðə sʌn ʃɔn aut wɔrmli, ənd
imidjətli ðə travlər tuk ɔf hiz klok; ənd so ðə nɔrθ wind
wəz əblaidʒd tu kənfes ðət ðə sʌn wəz ðə strɔŋgər əv ðə tu.

The same Fable in 'Phonoscript.'

The north wind and the sun were disputing which was the stronger, when a traveller came along wrapped in a warm cloak. They agreed that the one who first made the traveller take off his cloak should be considered stronger than the other. Then the north wind blew with all his might, but the more he blew the more closely did the traveller fold his cloak around him; and at last the north wind gave up the attem(p)t. Then the shone out warmly, and immediately the traveller took off his cloak; and so the north wind was obliged to confess that the sun was the stronger of the two.

The U.S.A. National Education Association's Scheme.

Type of Joint Committee's Report

Fôr skôr ənd sevən yîrz əgô aur fâđərz brət fôrþ ən đis kənti-nent ə nyû nêʃən, kənsîvd in libərti ənd dedikêtid tu đə prəpəziʃən đət əl men ar kriêtid îkwəl. Nau wî ar ingêjd in ə grêt sivil wər, testiŋ hweđər đat nêʃən, sô kənsîvd and sô dedikêtid, kan ləŋ endyûr. Wî ar met ən ə grêt batəl-fîld əv đat wər. Wî hav kum tu dedikêt ə pôrʃən əv đat fîld az ə faınəl restiŋ-plês fər đôz hu hîr gêv đer laivz đət đat nêʃən mait liv. It iz əltugeđər fitiŋ ənd prəpər đət wî ʃud dû đis.

The same extract in 'Phonoscript.

Four score and seven years ago our fathers brought forth on this continent a new nation, conceived in liberty and dedicated to the proposition that all men are created equal. Now we are engaged in a great civil war, testing whether that nation, so conceived and so dedicated, can long endure. We are met on a great battle-field of that war. We have come to dedicate a portion of that field as a final resting-place for those who here gave their lives that that nation might live. It is altogether fitting and proper that we should do this.

Dr. Wilfrid Perrett's 'Peetickay.'

from ð ˈtɯmz ˈlitrr' s-plɯm, 8/viii/18

"sk·lrz hɪ prɯd ð·slvz ·n ð/r lrniŋ z s-mþiŋ ·v hwitʃ ð m·s ·v m/n -r ink/p-b·l -r tr/t·rz tɪ sk·lrʃip, ·r prɪv ð ð/ -r ignrnt ·v its vr' s-bjɪkt-m-tr. tɪ bɪ prɯd ·v sk·lrʃip iz tɪ þiŋk ð yɪ hv m/d ð ˈtrn·l yɪr yn prɯvɪt p·zʃn, hwitʃ mɪnz ð yɪ hv nvr ɪxplr'nst it ·t·l."

The same extract in 'Phonoscript.'—

(From the 'Times Literary Supplement'—8·viii·'18.)

"Scholars who pride themselves on their learning as something of which the mass of men are incapable are traitors to scholarship, and prove that they are ignorant of its very subject matter. To be proud of scholarship is to think that you have made the eternal your own private possession, which means that you have never experienced it at all"

Note:— The above is representative of my own personal pronunciation, and is more 'colloquially' phonetic than Dr. Perrett's transcript. —— A. E. H. ——

The Simplified Spelling Society's Scheme. The same specimen in 'Phonoscript.'

Gerlz and boiz
Kum out tu plai,
Dhė moon duz shyn
Az bryt az dai;
Leev eur super
And leev eur sleep,
Kum tu eur plai-feloez
In dhe street.

Kum widh a whoop
And kum widh a kaul,
Kum widh a good-wil
Or not at aul;
Up dhe lader
And doun dhe waul,
A peni loef
Wil serv eu aul.

Girls and boys
Come out to play,
The moon does shine
As bright as day,
Leave your supper
And leave your sleep,
Come to your play-fellows
In the street.
Come with a whoop
And come with a call
Come with a good-will
Or not at all;
Up the ladder
And down the wall,
A penny loaf
Will serve you all.

Specimen of Prof. Craigie's Scheme.

It wàs̄ enòu·gh̄ tó make me lāugh̄ (*or* lăugh̄). I caught my cŏugh̄ th̄roūgh sitting in a drāugh̄t. The lĕather is̄ bōth̄ ròugh̄ and tòugh̄.

The sc̣hŏlars̄ còme home from sc̣hool singing in c̣horus. That wàs̄ the c̣hĕmist's sc̣heme. He hàs̄ c̣hrŏnic cata·rrḥ of the stòmac̣h. The mŏnarc̣h seeks tó conqụer his̄ foes̄. The barqụe cast anc̣hor thêre.

God save our graćịòus Qụeen. He is̄ conṣćịòus of hăving a spĕćịal miśśịon. It wàs̄ a vĕry änćịent and prĕćịòus th̄ing. He is̄ śūre tó leạrn Frenćh this seśśịon. I lost patịençe and wàs̄ not cautịòus enòu·gh̄. Dó not mentịon so slight an actịon. We hăve little notịon how larǵe the Ruśśịan natịon is̄.

I shall dó it with plĕas̄ure. I hăve vīs̄ịons̄ of lĕis̄ure sòme day. The hos̄ịer tóok the mĕas̄ure of my fóot.

The specimen of Phonoscript given below has been written by one of the teachers, Miss E. M. Smith, to show the unobtrusive character of the stress-mark where such indication is necessary :—

The following quotation is written with a broad nib.

"The English Language is now spoken by more than twice as many people as have any other European tongue for their native speech. It bids fair to become the world language of the future. For this function it is admirably fitted by its grammatical simplicity and by its flexible vocabulary. The chief obstacle in the way of its extension is the barbarous complexity of its spelling."

Professor Brander Matthews.

(Space forbids the reproduction of other slides shewn giving specimens of the solutions devised by Prof. Jespersen, Dr. Frank Vizetelly and Miss A. Deane Butcher, and one shewing a transcription of the Dorsetshire dialect in Phonoscript.)

You will have observed that in all the transcripts exhibited, except Phonoscript, their authors have secured the effects they desired by the use of one or more of the following devices :—entirely new characters, inverted or reversed letters, non-initial capitals and unattached diacritics. All in class (*a*) change the orthodox spelling, and imply double printing or writing, or involve a considerable period in training in transference to the usual orthography. The scheme of the Simplified Spelling Society is, as I have before pointed out, a compromise. It does not employ new, reversed or inverted letters, diacritics or non-initial capitals. It is the result of the long and careful collaboration of a very able body of experts, but it has grave inconsistencies and serious omissions. It has been employed with marked success in the teaching of reading to young children, and in that function it has received my ardent advocacy and support. In view, however, of the fact that recent demonstrations have shewn that this method, even when used by very clever teachers, occupies at least fourteen months, four of which are needed to effect the transfer to orthodox spelling, while Phonoscript can be, as you have seen this evening, effectively taught in less than three months and involves no such transfer, I am unable any longer to maintain this sympathetic attitude. The Simplified Spelling Society's method has another decided drawback in common with all the schemes necessitating a change of spelling. When once the transfer has taken place, and the pupil attempts with a very limited vocabulary to read a book in ordinary spelling, every new word presents the same difficulty as it does to the scholar taught by the commoner processes. A book printed in Phonoscript, however, while preserving the ordinary word-picture and easily legible by any reader entirely ignorant of the phonetic markings, gives the student in case of doubt a perfectly accurate pronunciation key.

The objections to the employment of the other devices referred to above, namely, the use of entirely new, inverted, or reversed letters, non-initial capitals and detached diacritics have been so frequently and forcibly expressed by others, that I need not repeat them.

The advantages which I venture to claim for Phonoscript are, briefly stated, that it employs none of these devices and preserves from first to last the ordinary word-form. It involves no contradictions, no exceptions, no rules. It is completely acquired by one simple mental movement only, and that the most rudimentary of which the human brain is capable, namely, the direct association of two sense impressions—an impression of sight linked with an impression of sound. No mental process can possibly involve less expenditure of nervous energy than this simple union of two sense impressions. It is the process by which the infant acquires all its early knowledge. This method is, therefore, suitable above all others for the instruction of dull or defective children. Two of the children you have heard this evening belong decidedly to the "dull" or "backward" category.

The teaching of reading may now be robbed of all fear or doubt on the part of the pupil, and all worry and drudging "grind" on the part of the teacher. It needs no elaborate apparatus, no coloured devices, no clever story-telling, no mastery of the jargon of scientific phonetics.

Phonoscript does not profess to be a method of spelling reform, but I am confident that it will prove the most potent fore-runner of that much-desired change.

The most perfectly scientific scheme of spelling reform has no chance of adoption unless its prospective users have been educated to an appreciation of its necessity. The failure of the propaganda of the Simplified Spelling Society and other similar organizations is due to a lack of appreciation of the psychology of receptivity. Dr. Wilfrid Perrett in his recently published book *Peetikay*—a book, by the way, sparkling with caustic wit and genial humour—puts this point very clearly. He says, in his amusing way, "no thorough reform in the writing of English, however perfect and scientific the correspondence between sound and symbol, is likely to win its way unless there is an easy transition from old to new. Children under five might begin with a clean slate ; their elders cannot do so if they would, and the majority of these have no use for slates at all, except in their proper place on the roof. There are too many loose slates flying about."

Well, you have seen on the screen a specimen of the learned doctor's *Peetikay*; I will leave you to judge how far he has fulfilled his own condition of acceptance.

Phonoscript is founded on the new manuscript or print writing now increasingly taught in the schools. To these most simple letter forms are added the lines, loops and curves commonly used in ordinary cursive penmanship. These familiar attachments are supplemented by a few others of similar design. The main form of every letter remains dominantly distinct, and the usual word-picture is fully preserved. Every letter that can be written in ordinary handwriting, without lifting the pen, can be so written in Phonoscript. It has been proved that the youngest pupils have no difficulty in forming any of the characters employed.

In conclusion, permit me to express my earnest hope and firm belief that Phonoscript may, and will, not only effect a much-needed reform in the teaching of our tongue in all the English-speaking lands, but that it will do much to advance the great objects for the attainment of which the English Language Union exists—the extension of the study and use of English as a World-Speech, as the medium for the pooling of the world's best thought, and as a potent instrument of international understanding and goodwill.

DISCUSSION.

In reply to a question about the stress accent on words, Mr. Hayes said the stress accent was marked in the International Code by a stroke, but he thought a stroke was too obtrusive and he therefore adopted the following plan. Words which had the accent on the first syllable were left untouched. If the word was a long one and had the accent transferred to any other syllable, a dot was placed not above the letter but between two letters and preceding the accented syllable. He wished to point out, however, that the very fact that phonoscript gave the obscure neutral vowel sound wherever it occurred in actual speech obviated to a very large extent the necessity for any accent indication at all. Every language was in a large measure characteristic of the people who spoke it. French had an evenly distributed accent, and it was characteristic of the smooth machine-like logic of the French mind. Englishmen were supposed to grasp the essential and be contemptuous of the less essential, and so they were in their language. They stressed the dominant syllable and let the other syllables take care of themselves. If those subordinate syllables were given the neutral vowel sound that was so often used in English—and which must be used if the language was to retain its characteristic beauty—and if it was so written in phonoscript, the accent largely took care of itself and did not even require a mark.

In reply to a question as to whether he maintained that children of three could master in less than three months the whole of the two pages of the phonoscript key that had been shown on the screen, and apply them to words, Mr. Hayes said that personally he would never teach a child under six any reading at all. He was not going to do it at his own school, but in the present instance he had had children of five taught to read by the phonoscript method in order to prove to those who did not think as he did that it could be done. He most emphatically did not believe that children under six should be taught to read except in those special cases where the curiosity and precocity of a child were so marked that they ought to be satisfied. He would never think of attempting to teach reading to children of three, but with regard to children of five the demonstration given that evening had proved that after fourteen lessons they could give the correct sounds of 47 characters. It would be impossible to give those children any word in the English language that they could not correctly sound.

In reply to a question as to whether in a class of forty, fifty or sixty children the whole of them would be able to learn the sounds in the time mentioned, Mr. Hayes said it would be absurd for him to state that all the children would equally well acquire the knowledge, but after phonoscript had been taught for five weeks at his school, five headmasters and five assistants visited it and were at liberty to throw any word they chose on the blackboard, and they did not give a single word that the children could not read.

Miss A. Deane Butcher said she thought the author had proved that spelling reform was an absolute failure and that reform should be in the direction of printing, altering the shapes of the letters or adding signs to them either apart from the letters, as in orthotype, or joined to them, as in phonoscript. Orthotype was not invented to teach children to read. When she was a child children taught themselves to read. She herself, at the age of four, could read anything that she could understand, and she had asked a great many mothers at what age their children learned to read, and often received the answer that they taught themselves. All that was necessary was to interest them in the subject about which they were reading. Orthotype was not originally invented for children, but to teach English to Italians. It was intended to indicate everything that the human voice could say in

any language all over the world. It had been learned since the war that no teaching was of any use that was not international. The system called orthotype was patented in this country in 1907, and was published in Canada a year or two afterwards, and adopted there by the Minister of Education for the teaching of 40 different nationalities. Therefore it was an older system than phonoscript, and she was very glad to say that the author had infringed her patent! The author required money to make his type, and the number of women present at the meeting proved that it was a women's question. The men ought to do their part and provide the money for the women to spend; that was a very good way of sharing the duties of the community.

Mr. Cloudesley Brereton said he was taught to read by a method called "Reading without Tears," and he did not think there was ever a greater misnomer than that. Although he was an Inspector he had attended the meeting as a learner and confessed that he was going away very much impressed. The author had made some very remarkable points. As expert to the London County Council for Modern Languages, people from time to time asked to have an interview with him, and in most cases they claimed to have an entirely new system of teaching modern languages, but after a certain amount of conversation he found that the system was as old as the hills or was of no use whatever, or merely touched a fringe of the subject. He mentioned that point because he had been struck by the fact that the author, although he had had a large number of predecessors in his particular field, spoke very kindly of them all; he did not run them down to magnify his own particular system. There was only one predecessor the author did not mention in his exhaustive list, and that was Mr. Squeers, who said: "W-i-n-d-e-r, winder, go and clean it." That was not a system to be laughed at, because it was partly adopted in the present method of teaching modern languages: an attempt was made to attach the sound not merely to the word but to the object. It was a very useful method, provided the word was spelt right! He noticed in the demonstration that the children nearly always spoke in chorus, and he would like to know what the children individually could do, because that was the supreme test. He had made up his mind to visit the author's school and test the children individually. He remembered that many years age, when he was being prepared for Confirmation, the boys in the class he attended were allowed to say their Catechism in chorus, and on one occasion when the best boys happened to be away, during an epidemic of influenza or some other disease, the class performed in an atrocious manner. He did not say that would be the case with the author's children, but he would certainly like to hear them individually.

Mr. Hayes, replying to Mr. Brereton, said it was well known that chorus answering was deceptive. A great many teachers had visited his school and had seen all the classes at work as a whole, and if they had been at all observant they would have noticed that there was what was commonly called a "tail." There was a "tail" in every class. But what he wanted to point out was that when a child had to be corrected he had only to be reminded that he had forgotten the sound for a single sign; the child had not to be reminded of the different rules for pronouncing an "a" long or short, and so forth.

Mrs. H. Samuel said she was exceedingly glad to have been present at the meeting, as she had never heard of any system that seemed so nearly to approach perfection as that which the author had described. All her life she had been troubled with new ways of teaching reading; there was the Ramsay Cooper system and simplified spelling, and at the present time she was in a school where there was a dual system of teaching reading, simplified spelling and the Sonnenschein system. She wanted to find some middle path and to introduce a common system. If the London County Council would allow the experiment and print books in phonoscript, and if the author would supply her with the key, she was prepared to make an intelligent, thoughtful and conscientious trial of the system. She had been head teacher in infant schools for 25 years and had known so many different systems that she never believed in anything until she had tested it herself. Phonoscript was the only system she had seen where something *in* the letter denoted what the sound was to be. The Welsh language had exactly the quality which the author had introduced into phonoscript, *i.e.*, there was one symbol for one sound. It was because of the enormous difficulties of the English language, which never seemed to have been overcome by any of the various methods introduced, that she had been so eager to hear the author's paper, and he had converted her far more quickly than anyone else had ever done. She would like to visit his school and learn more about his system.

In reply to a question as to whether any books had been published dealing with phonoscript, Mr. Hayes said that his publishers, Messrs. G. P. Putnam's Sons, hoped to have a Teachers' Guide, with full instructions how to set about teaching the system, and also two short Primers, ready in about a month's time.

On the proposition of The Chairman, a hearty vote of thanks was accorded to Mr. Hayes for his interesting paper.

Mr. Hayes expressed the thanks of the meeting to Dr. Maclean for presiding, and The Chairman, in replying, said the question of some form of writing that would make the English language easier to understand was a question not only of saving the time of children but of helping to make English the universal language of the world, as he trusted it would be within a century. There were many schemes proposed and many publications on the subject, and in America as well as in this country it was realised how futile compromises were with reference to simplified spelling, which was making very little headway. The Philological Society of the United States and the Philological Society of London, of both of which he was a member, had come to realise that what had been ridiculed as the stereotyped and troublesome spelling inherited by English-speaking people, was after all a very valuable achievement wrought out by printers of great intelligence, and that that spelling must be preserved in some form with some system to interpret it.

At the conlusion of the meeting Mr. Hayes invited anyone who was interested in the subject of phonoscript to visit Holy Trinity School, Kentish Town, any Thursday morning between 10 and 10.20 when the reading lessons were being given.

NOTES ON BOOKS.

Timber Technicalities. Compiled and Edited by Edwin Haynes. London: William Rider & Son, Ltd., 6s. net.

This new work, edited by Mr. Edwin Haynes, who has for so long been the Editor of *The Timber Trades Journal*, will supply a distinct need for the office desk, and also for the library.

In these days there are such a number of technical terms that the layman may be pardoned if he is not familiar with them all, as even the most modern dictionaries fail to give the requisite information.

In addition to the mere puzzle of terms, there is the great growing use of abbreviations for terms used not only in commercial correspondence but also in the daily press, so that the author is to be congratulated in undertaking the compilation of this work, and on his success in placing before the public a handy book for reference.

As a test of its utility, the reviewer took at random the word "Snape," and turning up the word in alphabetical sequence, he found on page 127, a very terse definition. Then he looked for "Dunnage." This appears on page 43. There are 163 pages of such matter.

The Appendices giving not only timber technical terms, but also office, banking, insurance and chartering terms, the feetage per standard when planed as against the rough sizes, and weights of English timber and foreign lumber. The glossary of timber trade technical terms in five different languages, is a striking feature of the work, and to shippers wishing to open up foreign connections, even if unable to write properly in the language of the country, it is a consideration and help to have these terms available.

Frank Tiffany.

Cotton and Wool. By J. S. M. Ward, B.A., F.R.Econ.S. London: William Rider & Son, Ltd. 10*s*. 6*d*. net.

The Tin Resources of the British Empire. By N. M. Penzer, M.A., F.R.G.S., F.G.S. London: William Rider & Son, Ltd. 15*s*. net.

These two works are the first and second volumes of a series of handbooks on the raw materials of industry, which Messrs. William Rider & Son, Ltd., are publishing. In the first, Mr. J. S. M. Ward, who is head of the Intelligence Department of the Federation of British Industries, deals with two very important raw materials of the textile trade, cotton and wool. The cotton problem at the present day is causing grave concern to the leaders of the industry. The falling off of production in the United States, coupled with ever increasing demand for more material there, threatens to produce a shortage of so serious a nature that, in the words of Sir Herbert Dixon, who contributes a brief introduction to the book, "in the general scramble for cotton many will be left out in the cold, operatives will be thrown out of employment, and the present abnormally high price of all cotton goods will not only continue but will very possibly go higher still." It is therefore essential that those who are vitally interested in the industry should understand the situation, and they will find this very thoroughly yet simply explained by Mr. Ward.

The supply of cotton is not keeping pace with the demand. The United States crop fell from 14,766,467 bales in 1914-15 to 11,547,650 bales in 1917-18, and in the same period the world's crop fell from 19,578,954 bales to 17,164,650 bales. Meantime the demand for cotton goods is immense, or would be if those countries which have been all but ruined by the war, could afford to buy them, for at the present moment, as has been said elsewhere, we are practically faced with a naked world. Various causes are given by the growers to explain the falling off in production, *e.g.*, shortage of labour and lack of sufficient artificial fertilisation; but, whatever the real reason may be, it is clear that unless some definite improvement is shortly seen, the situation will become extremely serious.

Mr. Ward discusses the question of increasing the world supply of cotton. There are only three considerable areas where any large increase seems possible. The West Indies, where Sea Island and similar grades of cotton of the finest

qualities can be grown, offer some hopes, although the area available is comparatively small, and labour difficulties are great. India and the former Turkish Empire are two important areas, but hitherto India has not succeeded in growing the higher grades of cotton such as are in demand in Lancashire. It is hoped, however, that with the application of scientific methods improvements may be made in this respect. The third area is Mesopotamia, where irrigation schemes will bring under cultivation large districts suitable for cotton growing. "Now that this area has passed under British control," writes Mr. Ward, "there seems a real prospect of something effective being done, and it is sincerely to be hoped that the opportunity now created will be taken advantage of at once."

In the section of the book which deals with wool, Mr. Ward urges that the great wool associations should take steps towards ameliorating the wool situation, similar to those which have been taken by the Cotton Growers' Association, in connection with cotton. The shortage of wool is comparable with that of cotton, and it is becoming more and more important that the sources of supply should be increased. Mr. Ward is of opinion that such increases might be obtained from India, South Africa, Palestine, Mesopotamia, British East Africa, and especially from Canada, which could carry at least ten times as many sheep as she does at present without in any way disorganising her agricultural output.

The situation with regard to tin is in some respects similar to that with regard to cotton. It is difficult, as Mr. Penzer explains, to obtain accurate statistics of the world's output: in the first place the figures are apt to be unreliable, and when they are procured it is not easy to reduce them to a common basis, as some of them are given in terms of tin ore, while others are only export figures. According to a table quoted from Mr. L. H. Quin's *Metal Handbook and Statistics*, the world production of tin fell from 113,308 tons in 1914 to 106,417 tons in 1919. The result of this shortage and of the steadily increasing demand for the metal is that its price rose from £191 14s. 0d. in January, 1912, to £376 12s. 9d. in January, 1920. A very large proportion of the world's supplies of tin are mined within the British Empire, and it is of the greatest importance that a readable and succinct account of the Empire's resources in such an important article should be available. We possess tin mines in all the continents, and Mr. Penzer describes in turn those in Great Britain, Malaya, the Indian Empire, Ceylon, Hong-Kong, Nigeria, The Gold Coast, Nyasaland, South Africa, Rhodesia, "German" West Africa, Canada, and Australasia. A number of photographs are given which help the reader to understand the methods of working the mines in the various parts of the world.

Both of these volumes contain admirable and very full bibliographies which will be of service to those who desire to study the subjects dealt with in greater detail. We congratulate the publishers on having made such an excellent start in what promises to be an unusually valuable series of handbooks.

THE RAISIN INDUSTRY IN AUSTRALIA.

The centre of the raisin industry in Australia is a comparatively small district along the Murray River at the point where the States of Victoria, New South Wales, and South Australia meet. This area, which was described 30 years ago as "the most wretchedly inferior of all grazing lands, 30 acres of which would not keep a sheep," has been transformed by irrigation into one of the richest parts of Australia.

Of the 18 districts which market their fruit through the Australian Dried Fruits Association, which is a co-operative marketing institution, the largest is Mildura, the original irrigated fruit colony, on the Victorian side of the Murray. The watering of this land is controlled and conducted by the Mildura Irrigation Trust, with jurisdiction over 45,000 acres, of which 12,300 are planted. The Trust is managed by a Board of Commissioners elected by the settlers themselves. It has 70 miles of mains, 100 miles of laterals, and 207 miles of subsidiary channels, with five batteries of pumps, which are capable of raising 30,000 cubic feet of water a minute. The Mildura district produced in 1919, 3,535 tons of currants, 4,788 tons of sultanas, and 1,574 tons of lexias; 150,000 cases of fresh fruits were sent to market, 5,500 tons of grapes were used for the production of wine, while 850 tons were tinned.

The Merbein irrigation area, situated in the shire of Mildura and irrigated by a pumping plant installed by the Victorian Government, has 7,000 acres planted with vines and trees. A soldier settlement was established here in 1917 when Government assistance was granted to men returned from the war and who wanted to go on the land. Merbein has a large co-operative packing plant and a winery and distillery at which large quantities of brandy are manufactured annually.

A third irrigation district in the vicinity of Mildura is Nyah, a co-operative settlement, which was originally devoted to citrus fruits but is being converted into a vine country, and has 950 acres given up to raisins. A returned-soldiers' settlement has been recently established at Nyah.

Across the border in South Australia is Renmark, with 3,000 persons raising fruit on 5,000 irrigated acres so successfully that land there sells at £300 an acre. Additional settlements near Renmark are being planned, including one of 14,000 acres for returned soldiers. Renmark has a distillery as well as a packing plant. Raisin grapes are also produced in considerable quantities at Clare, 89 miles north of Adelaide.

Other South Australian settlements included in the jurisdiction of the Australian Dried Fruits Association are Berri, with a pumping plant equal to 1,000,000 gallons per hour, Pyap, Warkerie, and Angaston.

On the New South Wales side of the river is Curlwaa, a Government settlement of 1,318 irrigated acres.

All these irrigated districts are to be extended, and will probably receive great assistance from the new Murray River irrigation works, which are being constructed jointly by the Governments of Victoria, New South Wales, and South Australia.

Co-operation in various ways, writes the United States Trade Commissioner at Melbourne, has been one of the main elements in the success of the raisin industry in Australia, and this co-operation has not been confined to organized and semi-official institutions like the Mildura Co-operative Packing Co. and the Australian Dried Fruits Association, but includes the friendly assistance of one settler to another in his own particular problems.

Ninety-five per cent. of the growers of fruits to be dried market their products through the Australian Dried Fruits Association, which has adopted the trade-mark "Sun-raysed," under which trade-mark all the dried fruit of the Association is sold. The Association is spending a large amount of money annually on advertising throughout the Commonwealth. The money needed for advertising and other expenses is raised by a small levy upon growers, on a production basis. This charge, it is stated, has been made up many times by the higher prices which the dried fruit commands since it has been put systematically on the market under the title "Sun-raysed."

According to official figures for the season ended March, 1920, issued by the Association, the total production of dried fruits in the 18 districts covered by its activities, was valued at £2,000,000 in round figures, of which, roughly, two-thirds were raisins and the balance currants. Other dried fruits—apricots, peaches, pears, figs, prunes and muscatels—have been produced to an aggregate value of £200,000. Areas being planted, to be in bearing by 1924, will, it is expected, cause an increase of at least 50% in the foregoing figures.

GENERAL NOTE.

Cotton in Uganda.—Cotton easily maintains its position as the principal article of export from Uganda, according to the Annual Report of the British Cotton Growing Association, and a steadily increasing production my be looked for, especially when the means of transport have been improved. The area under cultivation during the 1920 season was much greater than in any previous year, being estimated at 207,100 acres, as compared with 155,550 acres in 1919. The 1919-20 crop is estimated to exceed 50,000 bales. Unfortunately there appear to be grave doubts as to whether, in the present depressed state of the cotton trade, the 1920-21 crop will all be harvested and merchanted on a commercial basis. The Council of the British Cotton Growing Association have been giving this question their most serious attention, and have arranged to purchase cotton to the utmost limit of their capacity, so that the native cultivators may not be unduly discouraged.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

Monday, June 20..Victoria Institute, Central Hall, Westminster, S.W., 4.30 p.m. Annual address by the Dean of Canterbury.

British Architects, Royal Institute of, 9, Conduit Street, W., 8.30 p.m.

East India Association, Caxton Hall, Westminster, S.W., 3.45 p.m. Mr. A. L. Emanuel, "The City of Surat: our old Gateway to India."

Tuesday, June 21..Statistical Society, 9, Adelphi Terrace, W.C., 5.15 p.m.

Anthropological Institute, 50, Great Russell Street, W.C. 8.15 p.m.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Sir Ernest Birch, "Visit of H.M.S. 'Malaya' to the East."

Wednesday, June 22..University of London, South Kensington, S.W., 5.15 p.m. Dr. A. D. Waller and Mr. J. C. Waller, "Experimental Studies in Vegetable Physiology and Vegetable Electricity." (Lecture VI.)

Faraday Society, Burlington House, W., 8 p.m.

Geological Society, Burlington House, W., 5.30 p.m.

Oriental Studies, School of, Finsbury Circus, E.C., 12 o'clock. Miss A. Werner, "European Expansion in Africa." (Lecture IX.—Egypt and the Sudan.)

Thursday, June 23..Botanic Society, Regents Park, N.W., 5.30 p.m.

Friday, June 24..Chadwick Lecture, at the Royal Society of Arts, John Street, Adelphi, W.C., 8 p.m. Dr. A. L. Bowley, "The Growth of Suburban Population in England, especially from 1881 to 1911." (Lecture I.)

Physical Society Imperial College of Science, South Kensington, S.W., 5 p.m.

Correction.—In Sir Charles Bedford's reply to the discussion on his paper, reported in the *Journal* of June 10th, two lines were unfortunately omitted in the final proof. The second and third sentences in column 2 of page 486 should read as follows:—"Many of the points of the Classen method had been considered in the process under discussion; for instance, it had been found that sulphurous acid which Classen had used was not of much use. The problem to a great extent was different because of the light lignification of straw; that was to say, the fibre was wrapped round with the substance called lignin in the case of wood," etc.

Journal of the Royal Society of Arts.

No. 3,579. VOL. LXIX.

FRIDAY, JUNE 24, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

FINANCIAL STATEMENT FOR 1920.

The following statement is published in this week's *Journal* in accordance with Sec. 40 of the Society's By-laws:—

INCOME AND EXPENDITURE ACCOUNT.

January 1st to December 31st, 1920.

Dr.

		£ s. d.	£ s. d.
To *Journal*, including Printing, Publishing, and Advertisements		4,541 7 5	
" Library and Bookbinding ..		77 9 10	
" Medals :—			
Albert	25 10 0		
Society's	27 7 0		
		52 17 0	
" Sections :—			
Colonial	72 6 9		
Indian	104 14 2		
		177 0 11	
" Cantor Lectures		173 8 0	
" Donation to Board of Scientific Societies................		10 10 0	
			5,032 13 2
" Expenses of Examinations ..			8,123 16 7
" House :—			
Rent, Rates, and Taxes		980 13 9	
Insurance, Gas, Coal, Expenses and Charges incidental to Meetings		581 1 1	
Repairs		159 6 2	
			1,721 1 0
" Office Expenses :—			
Salaries, Wages, and Pensions		3,158 12 6	
Stationery and Office Printing		797 8 2	
Advertising		11 0 0	
Postages, Parcels, and Messengers' Fares		247 7 4	
			4,214 8 0
" Committees :—			
General Expenses			51 14 6
" Interest on Bank Loan			62 12 5
" Juvenile Lectures			25 0 0
" Glazebrook Testimonial......			2 2 0
" Balance, being Excess of Income over Expenditure transferred to Capital Account (see Balance Sheet)			548 15 2
			£19,782 2 10

Cr.

	£ s. d.	£ s. d.
By Subscriptions	6,720 5 0	
" Life Compositions	1,550 18 0	
		8,271 3 0
" Interest and Dividends on Society's Investments	513 16 9	
" Ground Rents	373 11 9	
" Interest, Dividends, and Ground Rents from Trust Funds for General Purposes	505 1 7	
Do. from Building and Endowment Funds	22 7 5	
		1,414 17 6
" Sales, etc. :—		
Journal	269 2 8	
Do. Advertisements	703 2 1	
Cantor Lectures	24 9 7	
Leather Committee Reports	3 16 2	
		1,000 10 6
" Examination Fees and Advertisements in and Sale of Examination Papers......		8,842 10 10
" Charges for Expenses for the use of Meeting Room		253 1 0
		£19,782 2 10

TRUST INCOME AND EXPENDITURE ACCOUNTS.

Dr.

	£	s.	d.
To Balance forward	488	0	10
	£488	0	10

Cr.

	£	s.	d.	Trust Accumulations, December 31st, 1920. £	s.	d.
John Stock Trust—						
By Balance, January 1st, 1920	21	15	11			
„ Interest on Investments	3	10	2			
				25	6	1
North London Exhibition Trust—						
„ Balance, January 1st, 1920	34	9	9			
„ Interest on Investments	6	14	10			
				41	4	7
Dr. Aldred's Trust—						
„ Balance, January 1st, 1920	31	6	4			
„ Interest on Investments	7	14	5			
				39	0	9
Thomas Howard's Trust—						
„ Balance, January 1st, 1920	77	0	4			
„ Interest on Investments	19	19	8			
				97	0	0
Owen Jones Memorial Trust—						
„ Balance, January 1st, 1920	85	10	1			
„ Interest on Investments	15	13	4			
	101	3	5			
Less Cost of Medals and Prizes	42	13	0			
				58	10	5
Mulready Trust—						
„ Balance, January 1st, 1920	52	11	5			
„ Interest on Investments	5	5	4			
				57	16	9
Dr. Swiney's Trust—						
„ Balance, January 1st, 1920	40	0	0			
„ Ground Rents (Income from)	180	0	0			
	220	0	0			
Less Transfer to the Society's Income and Expenditure Account	140	0	0			
				80	0	0
Francis Cobb Trust—						
„ Balance, January 1st, 1920	20	16	11			
„ Interest on Investments	8	18	10			
				29	15	9
Le Neve Foster Prize Trust—						
„ Balance, January 1st, 1920	13	7	4			
„ Interest on Investments	5	16	0			
				19	3	4
Fothergill Trust—						
„ Balance, January 1st, 1920	21	14	7			
„ Interest on Investments	13	12	5			
				35	7	0
Trueman Wood Lecture Trust—						
„ Balance, January 1st, 1920	11	6	3			
„ Interest on Investments	32	14	8			
	44	0	11			
Less Cost of Sir Oliver Lodge's Lecture (including Printing)	44	0	11			
				-	-	-
Benjamin Shaw Trust—						
„ Balance, January 1st, 1920		2	8			
„ Interest on Investments	4	13	6			
				4	16	2
Cantor Trust—						
„ Interest on Investments	145	18	11			
„ Ground Rents (Income from)	141	0	0			
	286	18	11			
Less Transfer to the Society's Income and Expenditure Account	286	18	11			
				-	-	-
Davis Trust—						
„ Interest on Investments	78	2	8			
Less Transfer to the Society's Income and Expenditure Account	78	2	8			
				-	-	-
Sir George Birdwood Memorial Trust—						
„ Interest on Investments	36	15	0			
„ Cost of Sir Valentine Chirol's Lecture (including Printing)	36	15	0			
				-	-	-
Russian Embassy Prize Trust—						
„ Interest on Investments	5	0	0			
„ Prize awarded	5	0	0			
				-	-	-
				£488	0	10
1921. Jan. 1. By Balance brought forward				£488	0	10

BALANCE SHEET, December 31st, 1920.

Dr.

	£	s.	d.	£	s.	d.
To Capital Account—						
As on January 1st, 1920	28,120	10	7			
Plus Income and Expenditure Account Balance	548	15	2			
Plus Profit in redemption of Newcastle-upon-Tyne Stock	225	0	0			
Plus Donation to Building Fund	72	10	0			
				28,966	15	9
,, Trust Funds:—						
Capital Account	15,999	7	5			
Accumulations under Trusts Income and Expenditure Account	488	0	10			
				16,487	8	3
,, Sundry Creditors				3,370	14	8
				£48,824	18	8

Cr.

	£	s.	d.	£	s.	d.
By Investments (see Schedule)—				17,186	0	5
,, Property of the Society (Books, Pictures, etc.)				10,000	0	0
,, Trust Funds Investments (at cost, see Schedule)				15,999	7	5
,, Ground Rents outstanding:—						
Trust Account	94	18	0			
Society's Account	171	8	0			
				266	6	0
,, Subscriptions Outstanding				2,675	0	0
,, Sundry Debtors:—						
Journal	103	5	1			
Advertisements	231	3	2			
Repayment of Expenses for use of Meeting Room	142	16	0			
Income Tax recoverable	207	10	0			
				684	14	3
,, Paid on account of 1921 Examinations				974	0	0
,, Cash at Bank on Current Account (less cash in transit)				639	10	7
,, Ditto on Deposit				400	0	0
				£48,824	18	8

We have audited the above Accounts and Balance Sheet for 1920 *with the books, accounts, and vouchers relating thereto, and certify them as being in accordance therewith. We have verified the Bank Balances and investments.*

KNOX, CROPPER & Co.,
Chartered Accountants.

Spencer House, South Place, E.C. 2,
14th June, 1921.

SCHEDULE OF THE SOCIETY'S INVESTMENTS.

			Ground-rents (amount invested)	£10,496	2	9
£217	0	0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	158	8	0
£500	0	0	New South Wales 4 per Cent. Stock	415	0	0
£500	0	0	Canada 3½ per Cent. Stock	360	0	0
£100	0	0	Queensland 4 per Cent. Stock	80	0	0
£530	10	1	New South Wales 3½ per Cent. Stock	456	5	6
£500	0	0	Natal 4 per Cent. Stock	400	0	0
£321	15	9	Metropolitan Water Board "B" Stock	196	6	0
£6	0	0	New River Company Shares	6	0	0
£3,408	14	6	India 3½ per Cent. Stock	2,317	18	8
£500	0	0	South Australia 4 per Cent. Stock	400	0	6
£2,000	0	0	War Loan 5 per Cent.	1,900	0	0
				£17,186	0	5

The Investments are as valued on May 31st, 1917, with the exception of War Loan, which is at cost.

TRUST FUNDS INVESTMENTS SCHEDULE.

	£	s.	d.
Alfred Davies Bequest	£1,953	0	0
Mr. Swiney's Bequest	4,477	10	0
Mr. Cantor's Bequest	2,695	11	3
Mulready Trust	105	9	9
Howard Trust	571	0	0
Owen Jones Trust	522	3	2
Mr. Cantor's Bequest	3,278	16	6
	648	19	7
J. Murray and others, Building Fund	20	16	4
	38	11	0
Francis Cobb Trust	255	14	1
Le Neve Foster Trust	105	11	7
	42	2	1
John Stock Trust	70	4	0
Shaw Trust	93	12	0
North London Exhibition Trust	134	17	0
Fothergill Trust	272	7	6
Aldred Trust	154	8	0
Endowment Fund	394	7	0
"Trueman Wood" Lecture Endowment Fund	654	15	7
Sir George Birdwood Memorial Fund	734	19	9
Russian Embassy Prize	100	0	0

	£	s.	d.
Great Indian Peninsula Railway 4 per cent. Guaranteed Debenture Stock	£1,800	0	0
Ground-rents (amount expended)	4,477	10	0
Do. do. do.	2,695	11	3
National 5 per cent. War Bond, 1927	109	10	1
Metropolitan Railway 3½ per Cent. Stock	510	9	5
India 3 per Cent. Stock	423	0	0
Do. do. / Bombay and Baroda Railway Guaranteed 3 per Cent. Stock	2,573	10	0
India 3½ per Cent. Stock	20	10	0
5 per Cent. War Loan	54	18	0
New South Wales 3½ per Cent. Stock 1930-50	250	0	0
3½ per Cent. War Loan	100	0	0
5 do. do.	40	0	0
5 do. do.	100	0	0
5 do. do.	129	6	3
5 do. do.	184	15	0
5 do. do.	374	0	0
5 do. do.	210	17	6
5 do. do.	525	2	3
National 5 per Cent War Bonds 1928	654	18	0
5 per Cent. War Loan	674	0	0
5 do. do.	91	9	3
	£15,999	7	5

NOTICE.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One hundred-and-Sixty Seventh Annual General Meeting, for the purpose of receiving the Council's Report and the Financial Statement for 1920, and also for the election of Officers and new Fellows, will be held, in accordance with the By-laws, on Wednesday, June 29th, at 4 p.m.

At the Annual General Meeting the Council will propose the following resolution :—

That By-law No. 47, relating to the date of the opening of the session, be altered and amended by the substitution of the word "first" for the word "third."

The By-law, as amended, will read as follows :—

By-law 47.—"The Session shall commence on the first Wednesday in November, and shall end on the last Wednesday in June."

(By order of the Council)

George Kenneth Menzies,

Secretary.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

Tuesday, May 3rd, 1921.

Sir Robert W. Carlyle, K.C.S.I., C.I.E., in the Chair.

The Chairman announced that Mr. Raitt had been obliged to return to his duties in India, and that Mr. R. W. Sindall, F.C.S., had kindly consented to read the paper and afterwards make some observations of his own on some of the latest developments in connection with bamboo.

Mr. Raitt, in his paper, dealt with not only bamboo, on which he was a well-known expert, but also with grasses. At the present time he (the Chairman) thought that they in India had to look to bamboo mainly for paper-pulp supplies. Grasses might be used in the distant future, but in the immediate future bamboo seemed to have the greatest prospects. Mr. Raitt had done much to assist in bringing the manufacture of bamboo pulp to its present stage. He first made Mr. Raitt's acquaintance some 10 years ago at the Allahabad Exhibition, when he showed hand-made samples of bamboo pulp. At that time some of them had read Mr. Sindall's book but few had gone any further in the matter. Since then Mr. Raitt had done much on the manufacturing side and had for some time past been the Cellulose Expert to the Government of India. One or more mills

had experimented on a factory scale, and the Indian Forest Department had made essential enquiries regarding the different species of bamboo and their reproductive periods. It had also turned its attention to grasses, not only with regard to their reproductive periods, but also in ascertaining over what areas they grew. A short time should see bamboo pulp mills working on a considerable scale. The Government of India was starting a small mill to enable adequate experiments to be made. It was not enough to make the experiments on a mere laboratory scale. In the past Government had been largely dependent on what information it could get from mills. Millowners and manufacturers very naturally were not willing to part with information which had been acquired at very great expense, and it was only reasonable, in the case of such a great industry, that the Government should do what it could in the way of experiments and communicate the results for public information. The utilisation of bamboo on a large scale for pulp was one of great importance, as wood reproduction was comparatively slow, say 30 to 40 years, as against three or four in the case of bamboos. The supply of timber for wood pulp was not inexhaustible while the demand for paper was likely to increase very rapidly, especially in India and China, with their enormous populations. A very small extension in education in India would cause a great increase in the amount of paper required. Unless some source of supply other than wood could be tapped, prices would probably rise in the future, as they had in the past, to an unhealthy height. The state of the paper trade at present in this country was a good example of how disastrous a rapid fall in prices might prove to mills heavily stocked with expensive raw material; but to place the paper trade—and for that matter any other trade—on a sound basis, it should be able to rely on material unfailing in quantity and moderate in price. There seemed to be very good ground for believing that the utilisation of bamboo pulp on a large scale would be of great help in bringing about that state of things.

The following paper was then read :—

PAPER-PULP SUPPLIES FROM INDIA.

By William Raitt, F.C.S.,

Cellulose Expert to the Government of India, attached to the Forest Research Institute, Dehra Dun, India.

It is a commonplace observation now that the question of the world's paper supply has arrived at an acute stage. We see it referred to in more or less lachrymose tones in almost every newspaper we take up. Our pockets test it daily in handing out twopences instead of pennies; the fivepenny five quire packet, with twopence for twenty-five envelopes, and the halfpenny newspaper have disappeared; and we are studying economy in a direction we never thought of before.

In 1913 the world's consumption of paper was estimated at ten million tons annually, increasing at the rate of 25 per cent. every ten years. It must be now nearly twelve millions, or would be if the supplies were available. Of this about 80 per cent. is produced from wood—coniferous wood and preferably spruce. In 1913, although there had been a slow but gradual appreciation of values during the previous ten years, it was still possible to deliver chemically prepared pulp in this country at £9 to £10, and mechanically prepared, or ground wood-pulp, at £5 10s. to £6 per dry ton, and newsprint paper could be produced for a penny per pound. Now values are four to five times these figures. The causes stated in order of their importance from lesser to greater are these :—

(*a*) The slow but gradual rise of values in pulp and all that it depends upon, dating from the period of lowest prices, about fifteen years ago. During the War this was, by reason of controls, restrictions, and reduced consumption more or less in suspense, but has now fallen on the industry with five years' cumulative effect.

(*b*) The universal appreciation in value of timber for constructional purposes. The sawmill is now a better market than the pulp factory.

(*c*) Effects of the War in permanently increased costs for labour, freights, fuel and machinery, and equipment.

(*d*) The total cessation for six years past of manufacturing expansion.

(*e*) The demand for wood has outrun the supply. The trees will not grow as fast as they are cut.

The last of these is the root cause of the trouble and is a constantly increasing menace. It does not necessarily imply that the world's stock of timber has been seriously depleted, but it does mean that the forests most favourably situated for exploitation—the areas which produced the penny per pound newsprint—have been largely reduced in productiveness and in many instances destroyed for ever. Expansion in wood-pulp production must seek its supplies at greater distance and increased cost. Notwithstanding this the

new values of pulp, making all allowances for temporary inflation, render such expansion abundantly justified. How much greater, therefore, is the justification for the introduction of a material which is one of Nature's waste products, which reproduces itself naturally and rapidly, for which no sawmill competes and which offers itself at Nature's valuation, which is next door to nothing.

So we ask ourselves the question, what can India do to fill the gap which has been created? The answer is a great deal, though not so much, perhaps, as is sometimes assumed. When the threatened shortage of paper supplies began to be agitated, some fifteen years ago, an eminent scientist issued what was intended to be a reassuring statement to the effect that "a paper famine was unthinkable, because paper could be made from any vegetable substance, and the world teemed with that." The dictum was seized upon by the Press and circulated round the world, and, no doubt, brought comfort to many anxious consumers. But like many other assertions of many other eminent scientists, it was, considered as cold fact, perfectly true, and at the same time, considered as a practical contribution to a difficult problem, perfectly misleading and fallacious. Paper can be made from any vegetable substance, but money cannot, and the paper-maker has a quite natural reluctance to make paper unless he can transform it into bank notes. But our eminent scientist's utterance gave rise to a whole crop of wild-cat proposals to make paper from everything, anything, and sometimes bordering on nothing. Nature, however, is not so fantastically generous as that. He whom she would favour must delve into her secrets slowly, deeply, carefully; hoping all things, proving all things, until finally he can hold fast to that which is good. This has been in essence the principle upon which the investigations of the Indian Forest Research Institute, to which I am about briefly to allude, have been carried on. We have thought it more important in the early stages of our proceedings to save people's money than to teach them how to make it, for nothing is more fatal to a promising industry than a disastrous failure at its start. At the same time, while paying considerable attention to the how-not-to-do-it programme and weeding out the "duds," we have met with encouraging success on the positive side. Our eminent scientist was an all-in, whole hog, hundred per cent. man. We have knocked ninety-five off that, but remain quite pleased with the five which have survived. The truth is that out of the hundreds of thousands of species available, a large number have to be rejected because of the cost of isolating their cellulose, a further large number because the cellulose is no good when you have got it, not to mention others which grow in economically inaccessible situations or are too valuable for other purposes. The net result is that so far we have found only two small groups, both belonging to the Gramineæ, which are economically sound as regards the quantity and quality of their cellulose and the manufacturing conditions under which they can be exploited. These are bamboos and a few Savannah grasses. But, though few in number, in the aggregate they mean something considerable. It is, I think, a modest estimate to say that from bamboo, taking only that which is available under *possible* manufacturing conditions, Burma, Bengal, and South-West India could produce ten million tons of pulp per annum, and Assam, from Savannah grasses, three million. India could, therefore, produce pulp for the whole world. Consider also the growth conditions under which this is obtainable. To grow a spruce or fir tree to pulp-wood size takes from 40 to 60 years, with the result that a factory which may at its start have its supplies at its back door finds these year by year receding into the distance with constantly increasing transport costs. Bamboos and grasses come to maturity as yearly or eighteen-monthly growths, and all you have to be careful of is not to reduce the reproductive vigour of the plant by too frequent cropping. With bamboo this may mean a three to five year rotation of cropping and with grasses two to three years. We must, therefore, have a sufficient area to exploit to allow of these rest periods, but that only means that for a ten thousand ton pulp output per annum, with average figures for yield and rotation, a 20,000 acre reserve will keep a factory going in perpetuance—a vastly different condition of affairs from those governing a wood-pulp installation which lives on its capital from the start or must adopt a re-afforesting policy, which reacts badly upon costs.

Bamboo for paper-making is no new suggestion. In the seventies the late Thomas Routledge, well known as the successful pioneer of esparto grass, experimented with it, obtaining encouraging results as far as quality and suitability were concerned but failing on the economic side, partly because of its resistance to bleaching but chiefly because just at that moment wood-pulp came in with a rush and more than filled the demand. In 1905 Mr. Sindall, at the instance of the Government of India, carried out an extensive investigation in Burma, with results considerably more encouraging than those of Routledge, though still somewhat disappointing on the bleaching side, and, at that date, cheap wood-pulp still controlled the market. In 1909 the Government of India, at the instance of Sir John Miller and Sir Robert Carlyle, who succeeded him as Member of Council for Revenue and Agriculture, deemed the time had arrived for a thorough enquiry into the whole subject, and handed it over to the officers of the Forest Research Institute, then under the Presidency of Mr. L. Mercer, Mr. R. S. Pearson, conducting the Forestry side of it. The chemical branch was begun at the Allahabad Exhibition of 1910, under the Presidency of Sir John Hewett, then Lieutenant-Governor of the United Provinces, and the directorship of Mr. P. H. Clutterbuck, Conservator of Forests, and afterwards continued at the Forest Research Institute. Hitherto the Institute's Laboratory work has been supplemented by tests at paper mills, by the courtesy of their owners, but Government has now ordered in Scotland a complete pulp and paper-making plant on a sufficient scale to permit of factory methods being used. This is to be erected at the Institute, and will immensely reinforce its usefulness. I would like in passing to call attention to Government's policy in thus carrying out the enquiries initiated by Sir John Miller, Sir Robert Carlyle and Sir John Hewett, as an evidence of its keen interest in the industrial development of the country.

The chemical branch of the enquiry was begun under conditions considerably more favourable than those with which Routledge and Sindall had to work. The uncertainties on the forestry side had been largely cleared up by Mr. Pearson's work, so there was no longer the risk of wasting time and effort on species and areas which he had shown to be of doubtful value. Considerable improvements had been arrived at in digestion methods, and particularly in the recovery and re-use of soda from the waste liquors, largely reducing the cost of chemical treatment. In Routledge's time a recovery of 40 per cent. was regarded as good; now from 80 to 90 per cent. is not unusual. Most important of all, market values of wood-pulp were no longer on the down grade, and the call for a new source of supply was becoming insistent. The problems to be faced were mainly those concerned with the cost of bleaching. It was evident that the dark brown colour of the unbleached pulp hitherto produced was not its natural and unadulterated colour, which in carefully prepared samples is a light grey faintly tinted with brown. The dark brown was a degradation result produced by the re-absorption by the *Cellulose*—which, as evidenced by its use in blotting paper, is one of the most absorbent substances known—of some of the complexes produced by the combination of soda with the solubles in the raw material. The first step in the enquiry, therefore, resolved itself into the isolation and separate examination of these. This resulted in the separation of the plant constituents into a series of groups, based on their degrees of solubility. Each of these groups is a complex one, exhibiting the group substance in several forms and types, all of which are of interest to the organic chemist, and upon which much valuable work has been done by Cross and Bevan and others—in fact, it is upon the foundations laid by Cross and Bevan that our work has been built—but what interests the pulp manufacturer chiefly is the problem of getting into solution the non-cellulose constituents of his raw material.

Proceeding on these lines it was found possible to separate the plant constituents into four groups having marked and striking differences of solubility. In order of solubility beginning with the least resistant they are :—

GROUP I. *Starch* and its secondary and transformation products—all soluble in boiling water.

GROUP II. *Pectose* soluble in one to two per cent. caustic soda solution at boiling temperature.

GROUP III. *Lignin* soluble in four per cent. caustic soda solution at temperatures over 130° C.

GROUP IV. *Cellulose*, the insoluble residue.

An average analysis of bamboo on these lines will give results in round figures as follows:—

Starch Group	12%	There is also a trifling amount of wax and silica in the cuticle which goes into solution with the Pectose group.
Pectose „	20%	
Lignin „	15%	
Cellulose „	53%	
	100	

The characteristics of the three soluble groups in their behaviour with soda are as follows:—

Starch in its primary form gives a clear colourless solution, but its quantity present in a total group content of 12% does not exceed a sixth. The other 10% of secondary starches form a dark brown nearly black solution of great pulp staining power. The *Pectoses* yield a dark brown staining solution which is gelatinous and therefore powerfully resistant to removal by washing prior to bleaching the pulp. The *Lignins* give a pale brown or amber coloured solution, clear, limpid and not gelatinous so that its faint stain is removable by washing. Now, since the raw material does not break down into pulp, and *therefore into a condition permitting re-absorption*, until the lignin has been removed, the next step seemed clearly indicated, viz., remove the substances which produce the objectionable stain on the pulp *before you attack the lignin*. It is fortunate that Nature has made her arrangements to facilitate such a separation process. She gives us a beautifully graduated ascending scale of solubilities combined with a descending scale of staining effects. Had the opposite condition prevailed, had the most resistant, lignin, been also the worst staining factor we should have come up against a dead end.

Cellulose and lignin in combination form that old acquaintance of our school days, woody fibre, yet the analysis is very dissimilar from that of the substance we usually describe as wood, which has a much larger proportion of lignin. The pectose group is replaced by a comparatively small content of resins and gums, while the starch group is barely recognisable in a small percentage of mucilage. The large quantities of starch and pectose found in bamboo and in all Gramineæ, are not in combination with the lignified fibre, but represent stages of transformation in the plant's laboratory of the primary food substance, starch, into the ultimate permanent products, lignin and cellulose. In speaking of lignin as a group, some qualification is necessary. It certainly exists in several types of varying resistance but not necessarily in the same plant. It is the substance which gives rigidity and resistance to the cellulose against the opposing forces of wind, rain and decay, and it does not appear likely that Nature wastes effort in providing annual grasses with a protecting medium of the same resistance as that necessary for a tree which may live for centuries, and this hypothesis is borne out by facts. Thus esparto grass, which exists for a few months, has only about 6% of a lignin which is capable of reduction at temperatures below 130° C., and may even be dealt with by strong soda solutions and prolonged treatment at ordinary boiling temperature, whereas wood may contain as much as 40% of a lignin which is strongly resistant to great density of soda at temperatures as high as 170° C. Bamboo, the life of which is not more than thirty years in the case of the longest lived species, is provided with a lignin intermediate to these in quality, capable of attack at 130° C. although not fully soluble under 150° C.; the difference between these figures being probably due to physical causes related to penetration of the reagent into a dense, compact and colloidally protected structure.

From these results we evolved the process which has been called Fractional Digestion, to distinguish it from the earlier method of overhead digestion—"overhead" in the sense that all solubles are dealt with together by a treatment drastic enough to secure the resolution of their most resistant member and, therefore, unnecessarily severe for the less resistant groups, which leaves the pulp steeped in a residual liquor, containing all the objectionable staining matter referred to. Such a system has for long been recognised as scientifically unsound, and we think we have proved it to be also economically unsound. It must necessarily be conducted with a large and wasteful excess of soda, first, because the lignin is not attacked until the digestion temperature has risen above 130° C., at which stage the starch and pectose groups have already been brought into solution, and have neutralised a considerable amount of the soda. That which remains will not be of sufficient strength to deal effectively with the lignin unless the original liquor contained a large excess. In this connection it is well to bear in mind the effect which density has upon

the activity of soda solutions. You may have present the total quantity of soda necessary to effect your object, but if it is distributed throughout so large a volume of water that density is reduced below a certain well marked degree you will not get the result you wish. A notable example of this is provided in the mercerisation of cotton cloth. The minimum density we have found necessary to give rapid and effective resolution of the lignin of bamboo is that represented by a 4 per cent. solution of standard caustic soda, and it must be of this density at the point at which the attack on lignin is commenced. Under the limitations of the overhead method, it will not be of this density at that point unless it carried, at the beginning of digestion, a very large excess. Now, since the theoretical quantity of soda required to neutralise the acid bodies, pectose and lignin, is only about 16 to 17 per cent., it is evident that the overhead method, with its consumption of 25 to 27 per cent., is compelled to employ and to waste a considerable excess.

A second reason for the use of this excess is one also imposed by the defects of the method. It does to some extent check the pulp-staining by holding more thoroughly in solution the gelatinous pectoses. It is a common observation among paper-makers that the more soda used the less is the consumption of bleach.

The best results hitherto obtained by the older method have been round about 26 per cent. of soda, calculated on the raw material weight and 16 per cent. of standard English bleaching powder, calculated on the unbleached pulp weight. These we have been able to reduce to 19 per cent. and 11 per cent. respectively, so chemical cost is now considerably below the best wood-pulp practice. Both sets of figures, for soda and bleach and for both methods, are subject to variations up or down of 1 to 2 per cent., in accordance with the slightly varying analysis of species. There is also a gain of 2 per cent. in pulp yield in the fractional system, owing to its less drastic conditions of both digestion and bleaching, and a considerable saving in capital cost of the soda recovery plant. In the overhead system the wash liquors used in leaching out the spent soda from the digested pulp are staining liquors and cannot be used again for digestion. They must go to the recovery plant, and as they are of low density they must be concentrated in an expensive multiple effect vacuum apparatus. As a result of the clean cut effected by the fractional method between the staining and the non-staining liquors the wash liquors can be used up in the chain of operations comprised in the regeneration of the recovered soda and the charging of the digesters. Only the digestion liquors need go to the recovery, and these are of sufficient density to be dealt with by a comparatively inexpensive concentrating and calcining plant.

In factory practice it is not necessary to deal with the starch and pectose groups separately. They can be extracted together by a one to two per cent. soda solution—the water deals with the former and the soda with the latter—and the liquor used for such combined separation is preferably that previously used for a lignin digestion as long as it contains sufficient free soda to effect the purpose. In quantity this is equivalent, for bamboo, to from 6 to 7 per cent. on the raw material weight. The high temperature lignin resolution should, therefore, be conducted with about 7 per cent. more than is necessary for the lignin treatment, thus giving it the advantage of high density already alluded to and securing that the residual liquor from the operation shall contain sufficient free soda to effect the pectose resolution in a subsequent charge of raw material. Both operations are, therefore, conducted with one volume of liquor, with obvious advantage to the recovery process, and there is also exhibited that curious property of some colloidal solutions that they are more effective solvents of another colloid than pure solutions. The pectose resolution may with advantage in hastening the process be conducted at temperatures higher than boiling, as long as these do not approach the point at which lignin begins to be affected. As this is somewhere about 130° C. we can safely go up to 120° C.

The figures given above are those resulting from the use of a "straight" soda liquor, that is, one manufactured from carbonate of soda, and of which the essential reagent is sodium hydroxide or caustic soda; but the modification known as the sulphate system is equally applicable to fractional treatment and with results corresponding comparatively for the two methods with those given above. With it the losses during the cycle of operations are replaced by crude sulphate of soda instead of car-

bonate, and the resulting digesting liquor contains caustic soda and sulphide of soda in the proportions of about three to one. For the overhead method it does possess advantages such as would compel us to use it were we tied to that system. These are:—

(*a*) The sulphide does more effectively deal with the gelatinous pectoses than caustic soda and so to some extent checks pulp-staining.

(*b*) The sulphide checks to some extent hydrolysis of fibre at high temperatures by the caustic soda and so results in a slightly higher pulp yield.

Its disadvantages are:—

(*c*) Sulphide has little effect upon lignin, and to maintain the quantity of caustic soda necessary to deal with it the combined total of this and sulphide is 2 to 3 per cent. more than is required with "straight" soda liquor.

(*d*) Crude sulphate of soda contains considerably less real alkali than the usual commercial form of carbonate, which is practically a pure article; consequently a larger quantity of the former must be imported at a high freight cost.

(*e*) The objectionable odour it evolves would rule it out in populous districts, though this will probably not apply in the localities suitable for bamboo pulping.

Since fractional digestion effectively gets rid of pectoses before the real digestion, that of lignin, begins, advantage (*a*) is cancelled out and advantage (*b*) considerably reduced in value by the lower temperature at which it is conducted, so the choice between the two is reduced to a question of the relative costs of the actual soda contents of sulphate *versus* carbonate of soda *plus* the 2 to 3 per cent. alluded to in (*c*). Where freight cost is high the lower soda content of sulphate and the additional 2 to 3 per cent. referred to may quite possibly leave the advantage with carbonate, notwithstanding the lower cost of the former at its point of origin.

It will be evident from the above that our efforts have chiefly been along the line of soda treatment. Considering that bamboo is a grass exhibiting all the characteristic chemical constituents of grasses in general, and especially in the large content of unbleachable starch and pectous matter, it seemed to us that success was more certain along the lines held to be essential with grasses already in use, such as Esparto, and the other standard system of treatment extensively used for wood, known as the sulphite method, has never been seriously proposed for these. But this does not rule out entirely the application of the latter to bamboo, and simultaneously with our efforts an investigation on such lines has been going forward in this country, the digesting liquor being a bi-sulphite of magnesia. It is uncertain if it will result in lower costs than soda treatment, but it will probably succeed in producing a distinctive type of pulp, which will be all to the good of bamboo, as a whole, and reinforce its claims as an alternative to wood-pulp. The latter is produced in about equal quantities by both methods, and each is valued for its distinctive paper-making qualities.

The preparation of bamboo prior to digestion has given rise to some difference of opinion. It is somewhat noteworthy that such differences as exist relate entirely to the practical details of treatment. No difference exists as to the suitability of bamboo for the manufacture of papers requiring high bleaching and printing qualities. As regards preparatory treatment two schools have arisen, the crushers and the chippers. Reduction to chips is the wood-pulp practice, and its advocates appear to be in danger of a wood-pulp obsession, which renders them somewhat blind to obvious differences between the two materials. They are undoubtedly entitled to make all the argument they can from the fact that crushing expands the volume of the material to nearly double, and, therefore, apparently reduces the capacity and output of the digestion to half that obtainable with chipped material. I say apparently, for the actual result is not quite so bad as that. By reason of its lesser resistance to liquor penetration crushed material digests in three-fourths of the time required for chips, so if the output of a digester charged with chips is represented by 15, the output of one charged with crushed material is not 7½, but 10. Further, crushing does not create any additional recurring costs, but merely a greater capital outlay for the additional digesters required. Still, the objection is a valid one and entitled to full consideration, but we think it is more than counterbalanced by what emerges from a critical study of the physical and constructional features of the two materials, thus:—

(*a*) The fibre bundles of bamboo lie perfectly parallel to each other with no cross-graining and no interlacing; they split cleanly and crush perfectly without reducing to dust. Wood will not crush without a considerable loss through dust.

(*b*) Bamboo is thickly studded with groups of sap canals, which run perfectly parallel throughout the whole length of the stem. In the dry material these are filled with air, which, being in a state of capillarity, is extremely difficult to dislodge, and, in the case of chips, offers a powerful resistance to the penetration of liquor besides adding to the buoyancy of the mass and tending to float a portion of it above the liquor. The splitting, which is the first effect of crushing, runs along these canals which are thus laid open to attack by liquor on their interior surfaces and the capillary air is got rid of. Wood presents no such feature

(*c*) Bamboo, throughout the entire length of stem, is of homogeneous one-aged, one season growth. Wood, if say, 60 years of age, has its heart wood 60 years old, while its outer ring of growth is one year old. Therefore it must contain differences in density and quality, and consequently there must be a proportion of undigested chips in wood-pulp digestion. There is no need for such a must in the case of bamboo.

(*d*) The nodes of bamboo, contrary to general belief, are not denser than the internodes. Their specific gravity is about five per cent. less. But they contain more pectose and lignin and their colloidal resistance to liquor penetration is, therefore, greater. The antidote to this is opening up their tissues completely. By crushing, this can be done so thoroughly that they can scarcely be distinguished in the general mass. As chips they must result in a considerable proportion of undigested specks and blemishes in the pulp.

The chipping school under the influence of their wood practice obsession are quite reconciled to the presence of this undigested matter in their pulp. They regard it as natural and expend their energies upon means of screening it out of the pulp after it is cooked. The crushers say it ought not to be there at all, that there need be no undigested chips in the pulp except occasional accidentals, due to particles of raw material getting lodged over rivets or otherwise hung up in the upper part of the digester beyond the reach of liquor, and they think this is a result well worth attaining at the cost of somewhat larger digester plant; and they claim further that since crushed material will digest with less drastic conditions of time, temperature and soda, the digestion cost is less and the pulp yield more.

In proceeding now to review the economic side of the matter, let us disclaim at once any intention of basing estimates upon the present values of chemical wood-pulp. These are about £35 to £45 per ton c.i.f. at British ports, according to quality, and undoubtedly represent temporary inflation. Any attempt to arrive at what may be the normal price of wood-pulp in this country when inflation has been worked off can only be a more or less intelligent appreciation of events, but considering that costs of production for labour fuel, chemicals, machinery, freights and wood are three to four times what they were in 1913, and that these advances are probably permanent, with wood still tending to rise, we shall not perhaps be far wrong in putting it at £28 per ton. If this is considered too high the sequel will show that it is a figure permitting of considerable variation downwards. On similar grounds we would put the future normal price of mechanical wood-pulp—which is not cellulose at all but only ground raw wood—at £16 per dry ton. Under the transport conditions I will describe later, bamboo can be delivered at manufacturing sites in Burma at a cost of 12*s*. 6*d*. to 15*s*. per dry ton, equivalent to from £1 11*s*. 3*d*. to £1 17*s*. 6*d*. per ton of unbleached pulp. Compare this with the like cost for wood-pulp, which is from £10 to £12.

Manufacturing charges, inclusive of liberal allowances for depreciation of plant and contingencies, will be under £10 per ton of pulp, so that the total cost on board steamer in Burma ports will probably not exceed £12 per ton—about the cost of raw material alone in the case of wood-pulp. In freights, of course, wood-pulp, being nearer, has the advantage, though not proportionally to distance, since port and terminal charges, no inconsiderable proportion of the whole, are the same for any distance. At present, from Burma ports, they are about £6, but this is abnormal, and I am advised on good authority that the eventual normal figure will not exceed £4. The prospects, therefore, are that bamboo unbleached pulp can be delivered

in this country at a cost not exceeding £16 to £18. Freights, again, are not entirely a matter of export in this country. There is a growing demand for India, China, Japan and Australia, and to these countries freights would be in favour of bamboo-pulp and against wood-pulp. The economic position thus disclosed has an interesting relation to mechanical wood-pulp, for which we have assumed a future normal value of £16 per ton. I do not think it has ever been seriously suggested before that a chemically prepared pulp could be brought within competition distance in cost with a mechanical one, but the figures given above do now suggest such a possibility, and it is not wholly a question of price. Mechanical pulp will not produce a useful paper by itself, and it adds nothing to the quality of a sheet. It is merely a convenient filler, make-weight and reducer of cost, and must be held together by a considerable admixture of true cellulose. No paper-maker uses it because he loves it, but solely because he *must* to get his cost low enough, and he will willingly substitute for it a true cellulose if it does not cost him very much more, especially since he is well aware that such a substitution enables him more effectively to use fillers, which are cheaper even than mechanical pulp, such as that good old stand-by, China clay.

Few industries are more sensitive to transport conditions. Including the product, six tons has to be transported in and out of a factory for every ton of product where coal is available. If wood fuel is used the total will be 8½ tons. It does not necessarily follow that each of the primary materials required—which are bamboo, fuel, limestone and imported soda—must be available under ideal transport conditions. It may be the case that some extraordinary advantage in one of them enables the manufacturer to raise his cost limit for another, but it is evident that next to the raw material transport is the ruling factor. Its importance may be illustrated by my own recent experience. During the past eight years I have been asked to revise some sixteen propositions for establishment of factories. Of these, only three failed on account of defects in the raw material supply, nine had to be rejected on transport conditions, and only four satisfied all requirements. Judging from enquiries I receive this phase of the question receives little attention and a sufficient supply of raw material appears to be popularly regarded as a satisfactory foundation for the industry.

In a previous paragraph I made a statement to the effect that India and Burma could produce ten million tons per annum under *possible* manufacturing conditions—possible, that is, with a normal value of £28 per ton in England—but the areas included in such a survey are naturally capable of being divided into best and second-best, and the best are probably not more than a fifth of the whole. They are to be found chiefly in the coastal belt of Burma and North-Eastern Bengal and Assam, with a smaller area in South-West India. I have myself explored a considerable area of the coastal region of Burma. where the transport conditions are nearly ideal — numerous rivers, many of them tidal to 100 miles from the sea, and with good rafting water above that intersected with creeks and connecting channels, and down which bamboo, felled upon their banks, can be floated to the manufacturing sites on deep water, or within easy reach of ports and anchorages by the aid of lighters. If wood fuel is not available—and it frequently is—coal from Calcutta or oil from Rangoon can be had, and limestone, also by water, exists at several places on the mainland or islands close to the coast. The only foreign import required carrying a high freight cost is the small amount represented by 15 to 20 per cent. of the total soda consumption.

There is one peculiar feature of bamboo as to which a warning should be issued, viz., the extraordinary phenomenon it exhibits of cyclical gregarious seeding and death. A few species do follow the usual rule of grasses in annual seeding and a few others seed sporadically, but most of the important ones flower in cycles of long period and gregariously, and each species has its own length of cycle. It goes on reproducing itself by shoots thrown up from the root year after year for twenty, forty or sixty years until, feeling old age approaching, it throws all its remaining energies into producing an enormous crop of seed and then dies. The new generation, although ultimately destined to produce culms which may be 120 feet in length and six inches diameter at the butt, throws up a first crop of diminutive stems, perhaps eighteen inches high and less than a quarter

inch thick. Next year brings a crop somewhat larger, and so on increasing year by year in strict proportion to the growing power of the plant to produce starch and store it in its roots, until, after from four to ten years—the period varying with species, soil and climate—it is again throwing up its full sized culms. Note also, as a striking example of Nature's silent dynamic, that these stems which, as I have said, may be 120 feet by six inches, are produced of full height and diameter in four months. It is one of the few plants which you can literally see grow. Its branch and leaf system are developed in its second season, and it is then fully matured.

It will be clear from this that a factory planted in a district without some enquiry having been made as to the seeding cycle, might find itself suddenly bereft of supplies for a prolonged period. There are two methods of insuring against this; first, the next seeding period may be known to be at such a date that supplies can be depended upon for a period long enough to secure an ample return on capital invested in the undertaking, and, second, the presence in the area of an alternative species which, as is invariably the case, does not flower at the same period. It is satisfactory to be able to add that most of the important species have seeded within recent years, or are now in process of doing so, as if Nature had anticipated the demands we are about to make.

The crisis now threatening the paper industry, and, it may be added, the large and increasing family of industries based on cellulose, of which artificial silk and celluloid are types, is no unprecedented experience. It is historic and oft repeated. Beginning with the failure of rag to provide for a continually increasing demand, the trade during the last hundred years has passed in succession through the phases represented by the utilisation of textile wastes, straw, esparto and wood, each in turn hailed as salvation and each in turn failing to cope with the requirements or finding a better market. It remains a fundamental axiom of the industry that it is a "picker up of unconsidered trifles." As the interests of other manufactures in a material increase so in proportion that of the paper-maker decreases. They can all pay more for it than he can. I have been trying for twenty-five years in various parts of the world to find a solution for this recurring trouble. As the final considered result of that experience I venture to express the belief that no permanent solution of it can be found, except in the vast stores of annual—and I lay much stress on the annual—products of the forests and waste places of tropical and sub-tropical regions. Enormous in their volume, frequently co-existing with splendid transport and manufacturing facilities, continuous and rapid in their natural reproduction and easily converted by modern methods, they provide a field of enterprise of which we may well hesitate to prophesy the expansion and wholly fail to see the end. And remembering recent experience when we found ourselves almost wholly dependent upon foreign supplies, may we be pardoned for uttering a little pæan of congratulation that such areas are within the Empire?

DISCUSSION.

Mr. Sindall then contributed the following observations:—

Mr. Raitt, in his address, shows that with regard to the preparatory treatment of bamboo for ultimate conversion into paper two rival schools are in existence which he describes as the "crushers" and the "chippers." The argument on behalf of the crushing school has been exhaustively presented and it would, therefore, be interesting to know the line of argument adopted by the "chippers," so-called.

In this case the stems of bamboo are passed through a special slab-wood chipping machine, which cuts the bamboo into small chips similar to those obtained by the treatment of slab-wood. It is stated that such a process gives a much greater capacity in the digester, with a closer and better packing of the material. The digester is more easily and quickly filled and owing to the closer packing of the material less liquor is required. This in its turn means the use of a stronger liquor and ultimately a much smaller quantity would need to be evaporated for the recovery of the soda. Messrs. Boving and Co., who have developed this system, state that they are able to fill a digester of a capacity of six tons by blowing in the chips in about half-an-hour. Experiments were made by them in Sweden on a large scale, some twenty tons of bamboo having been utilised for the purpose, and it has been proved that the product obtained is perfectly satisfactory.

This firm have given considerable attention to the question of economy in the production of esparto and bamboo pulp and are at the present moment engaged in the erection of a large

esparto plant in Scotland based on the most modern practice of pulp treatment and the methods being introduced are certainly worthy of close attention on the part of paper makers. The system as devised introduces many ingenious methods for economy in fuel and labour. The material is cut into small pieces, cleaned and dusted and then blown into the digesters. The requisite amount of caustic soda is run into the digester and the cooking proceeds by a new system of circulation. In present practice the material is cooked by blowing live steam into the mixture, with the result that the consequent condensation of the steam increases the volume of the liquor to be evaporated for the recovery of soda. In the new system the liquor is passed through the grass in the digester through an outside circulating system heated by high pressure steam in such a manner that the steam condensed is drawn off separately and utilised for heating washing water or cooking liquor. The volume of liquor in the digester in this case is not increased and a definite saving is thus effected.

It is proposed to utilise this condensed steam for heating up the cooking liquor so that the pulp is at once supplied with hot liquor and this again means economy in steam.

When the pulp is sufficiently cooked the pressure in the boilers is utilised to discharge or blow out the boiled grass direct to the washing tanks or diffusers. This method is substituted for the present system of allowing the steam to blow out into the air or into water. The practical result is that the black liquor containing all the non-fibrous organic compounds present in the original esparto has a density of something approximating 14° to 16° Twaddle as opposed to 6° or 8° Twaddle.

The clean pulp is flushed out of the diffusers by water, and passed over screens and sand traps similar to those employed for the production of wood pulp.

The whole process is continuous, requiring very little attention and appears to be a great advance on the present system.

The same plant can be used and has been carefully designed for the treatment of bamboo. It appears that the knots in bamboo offer no difficulty and certainly results obtained on such a large scale as that involved in the treatment of 20 tons should afford sufficient evidence as to the value of the method designed by them.

The most important development, however, in connection with esparto, bamboo and similar materials such as Indian grasses, is the treatment of the black liquor obtained during the process of digestion. When these materials are treated with caustic soda some 45 per cent. to 50 per cent. of the original matter is dissolved and the liquor is then highly loaded with organic matter.

In the earlier days of paper making this liquor was discharged into the open streams and rivers of the neighbourhood, but owing to the action taken by local authorities it became necessary to devise some method of dealing with this black liquor, the discharge into streams and rivers being forbidden. A method was found in a process by means of which the liquor was evaporated to a thick consistency, in which condition the mass would catch fire and could be burnt, the organic matter in solution acting as fuel for a more or less complete incineration. The organic soda compounds were thus converted into crude carbonate of soda, in which form, after boiling with a definite proportion of lime, it was re-converted into caustic soda. The methods of evaporation, economy of washing water and scientific control of the several stages of treatment were gradually improved, and the recovery process, at first regarded as the outcome of a mere whim on the part of obnoxious local authorities, soon revealed itself as an important factor in reducing costs of production.

Of recent years, considerable attention has been given to a more scientific method of recovery in the hopes of obtaining more valuable bye-products than combustible matter. Rinman's process for the conversion of the soluble organic constituents into definite bye-products of commercial utility, already well established for wood pulps in Sweden, has now been applied in these recent experiments with bamboo, and an estimate of bye-products available from a standard bamboo pulp mill having a capacity of 10,000 tons air-dry pulp per year (using 22,000 raw material) is as follows :—

Bye-products.	Estimated Kilos.	Price per Kilo.	Total Price.
1. Methyl Alcohol	388,000	3s.	46,200
2. Acetone used as petrol, etc.	330,000		
3. Ethyl-methylketone (petrol)	22,000	1s.	38,500
4. Light Oils (petrol)	220,000		
5. Heavy Oils (Diesel oil)	572,000	5d.	11,917
	1,650,000		£96,617

or 1,625 tons.

Rinman's process is carried out on the following lines. The black liquor already suitably concentrated to the required density is mixed with a small proportion of caustic soda liquor and a carefully calculated quantity of quick lime. This mixture when showing a density of about 40° Beaume is kept at a high temperature in proper store tanks. The mixture is fed as required into a number of iron trays to the depth of about 2 centimetres. These

trays fit into square shaped wagons, four of which are at one time pushed into the distillation furnace, which is perfectly airtight when closed up ready for the operation of distilling. The temperature of the oven is gradually increased to 200° C., the heat for this process being obtained by burning gases which are given off during the distillation process, any extra heat being obtained from a gas generator using coke. At 200° C. the excess moisture is driven off.

The temperature is raised to 300° C., and at this stage the bye-products given off are mainly crude methyl alcohol and hydrogen gas. These products are drawn off in a suitable manner.

At an increased temperature of 400° C. the bye-products obtained are acetone and light oils.

The whole operation of distilling occupies about 18 hours. The furnace is then cooled and the wagons drawn out of the apparatus, the contents of each truck being tipped into water and causticised with lime. The lime mud, which is necessarily contaminated with the carbon left from the distillation process, is dried in a rotary furnace and ultimately burnt at a high temperature in another rotary furnace heated from the gas generator already described. By this means the lime mud is reconverted into quick lime which can be utilised over again in the process of causticising the crude carbonate of soda obtained from the distillation furnace.

If the Rinman process proves commercially practicable on a large scale as applied to esparto and bamboo then the prospects for cheap bamboo pulp seem bright. The quantity of bye-products obtained as shown in the above table amount to nearly 10 per cent. calculated on the original raw bamboo. At present the story reads like a fairy tale but the fact remains that mills are being erected in Great Britain having all these new applications in view for the treatment of esparto and grasses and its application to bamboo is stated to be merely a matter of adaptation.

MR. E. F. HEYERDAHL, of Christiania, said that last year he investigated the sulphate process and made trials with different materials. He had had a long experience in the treatment of coniferous woods, and he had also been to South Africa, where a Norwegian Company had a concession for the utilisation of papyrus. He carried out experiments with that papyrus, treating it by the sulphate process; and then made experiments with wattle wood and crushed wattle bark by the sulphate process. Recently he had made experiments with bamboo. The author proposed to carry out his digesting process in steps, first taking away the starchy matter and pectoses by boiling water and very diluted caustic soda. The author claimed that the action of the sodium hydroxide on the lignins did not take place before 130 deg. C. That was right, and then most of the sodium hydroxide was already used up in dissolving the starch and the pectoses, but by the sulphate process there were two actual solvents on the lignine compounds, i.e., sodium hydroxide and sodium sulphide. Sodium sulphide was a very strong resolvent for lignin, especially at high temperatures, and he believed that sulphide acted more strongly on lignin than sodium hydroxide, over 130 and 140 deg. C. In treating bamboo, the sodium hydroxide would first dissolve the starch and the pectoses. That process would be completed at about 130 deg. C., and then the sulphide would begin to act and would completely dissolve all the lignins in the bamboo. Another point about the sulphide was that it did not act upon the cellulose fibres, and, therefore, higher yields were always obtained when the sulphate process was used, about 5 per cent. more yield on the material being obtained by using the sulphate process than by using the other process. When treating coniferous woods with sodium hydroxide a brownish coloured pulp was always obtained, owing to the fact that during the boiling the iron in the wood and the iron in the apparatus were dissolved by the sodium hydroxide and precipitated into the fibres. When the sulphate process was used, sodium sulphide dissolved all those iron precipitates and a light greyish pulp was obtained instead of the brown pulp. In all his experiments he had only used bamboo chips, as he considered the crushing of the complete culms was not economical from a practical point of view; it required more power and he believed it was not good for the fibre. With regard to the yields, with the soda process, by a proportion of 19 to 20 per cent., he had obtained 42 per cent. of unbleached pulp, requiring from 16 to 18 per cent. of bleaching powder on the pulp, and an average bleached yield of 37 to 39. With the sulphate process he obtained yields of from 43 to 45 per cent., with a consumption of bleaching powder of 12 to 14 per cent., the proportion of actual alkali ($NaOH$ Na_2S) being 18 to 20 per cent. When bamboo was cooked and made into a well boiled pulp it was very easy to treat. The washing process was very easily carried out, as the water penetrated through the pulp very readily, and the washing time was reduced to about one-quarter of the time required on coniferous woods. Chipping the bamboo without considering the nodes was not good; there were too many nodes in the material and there would be a loss during boiling of about 5 to 6 per cent. The culms could be pressed in pressing rollers and then the pressed culms allowed to pass crushing rollers, which opened up the nodes and did not crush the internodes. The flat pressed culms with the crushed nodes could be chipped into chips of ¾in. to ⅜in. in length.

By that process a loss of only about ½ to 1 per cent. of the material would be obtained, and at the same time the actual capacity of the digester could be utilised to deal with about double the amount of mate ıal that could be treated if crushed bamboo we e employed.

Mr. Heyerdahl exhibited to the meeting some samples of bamboo pulps.

Mr. Hamel Smith remarked that, having always been very keen on the utilisation of bamboo for paper making, he would like the author to say what sort of gospel it would be safe to preach to the tropics in the time to come. It was very easy to be too sanguine on such points as had been outlined that afternoon, but after hearing a paper such as that which had been read, one realised the many technical difficulties which arose. Any one who had been used to sugar plantations could not help feeling that bamboos should be able to be cultivated on the same lines. One grew the cane within a certain area of the factory, taking good care to have the factory rather low down, if possible, because then the loads could be run down hill and the empty trucks up hill with greater facility. Also in regard to the question of transport, one should centralise the roadways or waterways so as to remove the finished product with greater facility. The experience on one estate, it seemed to him, might help on the other. Whether the production of paper from bamboo would ever become a private enterprise seemed a little doubtful. It was one of the queries he had often been asked, and he had never been able to give any satisfactory reply. Probably those who had been in the tropics would know that bamboo had been rather in bad odour on account of mosquitoes. The last estate he was on used to have most beautiful bamboos surrounding it, but he believed that the medical authorities ordered them to be destroyed as they collected water after the rains, thus making a breeding place for mosquitoes. Would that sort of trouble rise in connection with large areas of cultivated bamboo for a factory? The sanitary authorities might raise the difficulty that the bamboos were inclined to encourage the presence of mosquitoes to a dangerous degree, and thus lessen the chances of final success.

Mr. Arthur Baker (Chairman of the Technical Section of the Paper Makers' Association) said the paper was the outcome of long and painstaking research in bamboo by Mr. Raitt, and showed what a great industry the paper trade was. In Canada and the United States the consumption of paper for newspapers alone was two million tons a year. Taking the question of bamboo and grasses, and considering it from the point of view of an industry which might be started in India, one had to look at the position of that country as a market. India was not a very big market for paper. He supposed that in pre-war days it used probably about 80,000 tons of paper a year, of which the Indian paper mills, some nine in number, produced about 32,000 tons. India had imported about 10 or 12 thousand tons of pulp, more than one-quarter of which had come from Germany and Austria. So that industry could not be started on any considerable scale. He agreed with the author as to treatment; he thought the sulphate process was undoubtedly the best, and that crushing was the correct method of dealing with the raw material. If bamboo was to be a raw material for the paper-maker, it would require to be made on the spot, as the sulphate process created rather objectionable odours which would not be tolerated in all communities. He thought bamboo would obtain a foothold in India for printings, and it might be exported to Australia, China and even South Africa. The question of the use of all new fibre materials resolved itself into an £ s. d. proposition. Unless bamboo could compete strictly with other raw materials, on an £ s. d. basis it would never become an industry either in India or anywhere else.

Mr. Roland Green said that during the war they had used bamboo by crushing under a power hammer and boiling it in esparto boilers, where they had not more than 50 pounds pressure. The conditions were not at all good: it wanted higher pressure and longer boiling. But they had found it quite satisfactory, and had had no trouble at all after the crushing had been arranged.

Mr. L. P. Andrews said it seemed to him that bamboo was a most extraordinarily easy material to handle, and he could not help thinking that it was going to be a great factor in the future.

Sir John G. Cumming, K.C.I.E., C.S.I., in proposing a vote of thanks to Mr. Raitt for his paper and to Mr. Sindall for his kindness in reading it, said it had been known to him for many years that Mr. Raitt had been making researches in India regarding the possibilities of paper-making. Mr Raitt, the Forest Research Institute, and the Department of the Government of India which controlled that Institute (of which the Chairman that afternoon had been one of the most distinguished members), deserved great credit for what had been done in that direction. His own interest in the matter was two-fold. He had been over a great part of the area both in Bengal and Burma, to which allusion had been made, wherein bamboo forests of the nature required were to be found. Secondly, he

was intensely interested in any form which industrial expansion in India might take.

MR. G. M. RYAN, F.L.S., late Indian Forest Service, in seconding the motion, enquired whether other plants and grasses had been examined for the purpose of finding out whether they were suitable for paper-making? For instance, there was one plant, a common weed really, which he thought might be utilised for pulp and which could be obtained in very large quantities in India, namely, *Calotropis*. The fibre was already of use, but with the bark combined he thought it might be made applicable for paper. He, therefore, would like to ask Mr. Sindall whether it would not be possible to use it for the purpose of paper, as it contained a large amount of cellulose? With regard to bamboo, unfortunately nearly all the areas where bamboos grew were really on poor soil and unfit for agriculture, so that he did not think private enterprise could develop the industry. Government would have to organise the areas referred to especially for paper. There was a very large demand in India for bamboo for huts, etc. Therefore, in considering the amount of bamboo which would be available for paper, a large quantity would have to be deducted for local needs. It would not do to infringe on the existing economic uses of bamboo. Many years ago in a district in the Bombay Presidency there used to be an area of about 500 square miles extensively covered with bamboo forests, which had now disappeared owing to the large demand for bamboo for dwellings of the people. He thought those forests should be resuscitated and that no effort should be spared by the Government to do this. Another important thing was fuel supply. Wood was in large demand in India, and the problem was how to get it for burning in the paper factories. Recently there had been discovered a means by which waste vegetation could be converted into solid fuel by the Wells process which had been established in Egypt. Half a million acres of ground had been taken up there for cultivation, and the scheme was first of all to grow waste vegetation to feed the machines which would convert it into solid fuel. For the purposes of transport, and other means, those machines would be of great use in manufacturing fuel from waste products around the paper-pulp factories; and he wished to point out what a great advantage the new process would be for India as regards obtaining fuel in this way.

MR. SINDALL, in replying to the vote of thanks, said that one or two interesting points had been raised on the general issue. He thought all were agreed that it was not a question of technical difficulty at all. The matters arising out of the actual treatment of the bamboo and the technical problems involved had been very largely settled. Nor were there any rival methods in use. As Mr. Baker had said, the whole question was one of £ s. d.—whether it was commercially possible. No private enterprise could possibly succeed unless there was a prospect of profit, and that was all the paper-maker or the pulp-agent was concerned with. With reference to the amount of bamboo available, the point raised by Mr. Ryan was an important one, because bamboo certainly had a distinct market value in the towns, and one would necessarily therefore be compelled to seek such regions in which bamboo was growing freely and where the cost involved was merely that of cutting down and collecting. It followed, therefore, that there would not be cultivation of bamboo as ordinarily understood, but a proper control of growth in areas allocated to or belonging to the mill. With respect to grasses, they were being used in large quantities by several mills. The difficulty with some of the grasses in India was that the yield was very low and therefore it was not a commercial proposition. The question of the suitability of bamboo in paper-making had been settled long ago. He supposed the reason why private enterprise had been rather backward in the matter was because it cost £100,000 to £150,000 to put down even a small mill in an enterprise regarded as somewhat speculative.

CORRESPONDENCE.

BLOOMSBURY SQUARE.

It appears to me that London is missing a great opportunity at the present time.

The east side of Bloomsbury Square is being pulled down, and were the Square reconstructed and continued over the site, a really fine square opening on Southampton Row would be the result and at a moderate cost would serve as a war memorial in which all Londoners would share.

Instead, the site is marked to be rebuilt as offices for an Insurance Company. No work has yet commenced, and, indeed, part of the existing buildings are not yet pulled down. Therefore I hope it is not too late to approach the L.C.C. on the subject.

As this tends more and more to be the junction of business London with the West End, a more suitable point for a really fine square in the Continental manner can scarcely be conceived.

HYLTON B. DALE.

ANGLO-AMERICAN RELATIONS.

Your issue of the 3rd June contains the report of a paper read by Sir Geoffrey Butler, K.B.E., on Anglo American Relations. In this paper the author says, "It was for want of appreciating this fact that British Liberalism

made its ghastly mistake of backnig the wrong horse in the civil war of the sixties." There is no excuse for this attack on "British Liberalism." It did not back the wrong horse. It maintained a friendly feeling for the Northern States, notwithstanding the great suffering of the population engaged in the cotton manufacture, caused by the blockade of the Southern ports by the Northern Fleet. "British Liberalism" caused the Government to maintain a strict neutrality, and to resist the suggestion of the Emperor of the French (Louis Napoleon), that we should join with France in a war against the Northern States in aid of the confederates. If I wished to use your excellent journal for party purposes I could say a great deal by way of retaliation.

ARNOLD LUPTON.

NOTES ON BOOKS.

A HANDBOOK OF LABORATORY GLASS BLOWING. By Bernard D. Bolas. London: George Routledge and Sons, Ltd. 1921. 3s. 6d. net.

This handbook is definitely instructional. No chapters on side issues are included, the three pages on the chemical nature of glass having merely reference to the chemical variations as far as they affect the mode of working or the result.

We find definite instructions in concise verbal stages which correspond to the manipulatory steps and the diagrams—of which there are many in clear outline.

Although no attempt has been made to include an actual description of the making of every form of laboratory apparatus, as produced at the glass blower's table, an endeavour has been made to include descriptions of methods and stages to cover all aspects of such work; thus, the instructions for making enclosed double-surface condensers and enclosed sphere-in-sphere condensers (pp. 37-38) largely interlock with instructions as to complex vacuum tube work in which a flat spiral or other large object may be enclosed in a bulb (p. 93).

The section referred to, in which a complex vacuum tube is described, also embodies a useful effort to work out the first steps of a systematic analytical study for discovering the stages of making in stable form any complex article which may be presented for examination; as, for example, a complex vacuum tube involving inner passages, full-size enclosures in globes and the use of glasses of greatly differing composition and fusibility for fluorescent and like effects.

The making of light and stable glass stopcocks is described and illustrated rather fully and many miscellaneous methods are embodied: as, for example, methods of fixing metal tubes to glass tubes by soldering, mention being made of the method recently described by McKelvy and Taylor (Jour. Chem. Soc., September, 1920).

THE CLAYWORKER'S HANDBOOK: A MANUAL FOR ALL ENGAGED IN THE MANUFACTURE OF ARTICLES FROM CLAY. By Alfred B. Searle. Third Edition. London: Chas. Griffin and Co. 1921. 21s.

Mr. Searle, who is well known in connection with the inner technics of pottery, gives us in 382 pages of rather small type an admirable and detailed handbook, which the potter may with advantage keep ready to hand for reference. In addition to the matter directly embodied in "The Clayworker's Handbook," the possessor is put indirectly into touch with much more, as the comprehensive bibliography of 10 pages well covers the whole international range of works on the potter's art.

The sequent divisions of the work under notice embody the study of clays and raw materials, preparation of clays, general machinery, transport, and pumping, drying, glazing, setting in kiln, kilns, firing, discharging, sorting, packing and dispatching, defects, waste, testing and analysis, tables and full index.

Machinery and works appliances are treated of in detail and the account of the pendulum-mill, so much used in the United States, is interesting (p. 80). Air separators—for what may be informally styled the fractional distillation of fine dust—are touched upon (p. 85), although these appliances are not at present very material factors in clay working, and the author gives a useful hint as to the advantage of the principle of centrifuging when embodied in an air-separator. We may call attention to the fact that an early form of the air separator, a form easy to construct and well adapted for laboratory experiments, is to be found in that remarkable and suggestive work "Mohr and Redwood's Practical Pharmacy," published in 1849, where on p. 230 is figured a device consisting of an iron mortar, to which a sheet iron rim is attached, the top of the rim being covered with a disc of soft leather through which the shaft of the pestle passes, this acting as the "piston" of a diaphragm pump; while circulation into a settling box is provided for by two valve-bearing tubes leading from the rim on the mortar to a settling box.

Practical hints form rather a feature of Mr. Searle's Clayworker's Handbook, and an example is afforded by the hint on page 85 as to repairing the fine metal sieves with which the potter sifts in an "atmosphere" of water. Repair by solder is recommended, but Mr. Searle tells us that "to prevent the gauze being burnt by the soldering iron, it is often wise to lay the damaged part on a steel block to take away the excess of heat."

The great and the small are well associated in a work which may be regarded as a concise cyclopædia for the potter, and we may congratulate both author and publisher on the detailed excellence of the book. The sub-headings in bold type very much facilitate use and reference, as they contrast well with the close setting of the text.

Journal of the Royal Society of Arts.

No. 3,580. VOL. LXIX.

FRIDAY, JULY 1, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

ANNUAL GENERAL MEETING.

WEDNESDAY, JUNE 29th, 1921; MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair. The One hundred-and-sixty-seventh Annual General Meeting of the Society was held for the purpose of receiving the Council's Report, and the Financial Statement for 1920, and also for the election of officers and new Fellows.

A full report of the Meeting will be printed in the next issue of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

TWENTY-THIRD ORDINARY MEETING.

MONDAY, MAY 30TH, 1921.

THE RIGHT HON. J. R. CLYNES, P.C., D.C.L., M.P., in the Chair.

The paper read was:—

IMMUNITY AND INDUSTRIAL DISEASE.

By SIR KENNETH GOADBY, K.B.E., D.P.H. (Cantab.), M.R.C.S., L.R.C.P.,

Specialist Medical Referee for Industrial Poisoning (London and Home Counties). Late Hunterian Professor, Royal College of Surgeons, etc.

It has been my good fortune for the last twenty years to inspect medically week by week the men and women employed in certain large white lead, lead smelting, lead rolling and litharge works; to study constantly and at first hand the more personal and human side of Industrial Poisoning and to apply the knowledge thus gained to concurrent research in my laboratory on the problems of early detection and prevention of lead poisoning.

During the last nine years, as Specialist Medical Referee (Home Office) for cases of industrial poisoning comprised in the third schedule of the Workmen's Compensation Act, I have had the additional advantage of studying many varieties of occupational disease.

Industrial or occupational disease may be classified into two main types—(*a*) Primary or Intrinsic, due to the specific deleterious material handled in the occupation such, for instance, as the metallic poisons, (*b*) Secondary or Extrinsic Disease, Non-specific to industry, which may be predisposed to by the occupation.

The cause of a large number of industrial diseases is known, and preventive measures, Home Office regulations, and special rules have produced an enormous diminution in their incidence. (See Tables 1-5.)

Now, although the exciting cause of most occupational disease is known, the individual factor of immunity and susceptibility has received scant consideration, nor are we in possession of detailed information of that individual susceptibility which I shall show plays so wide a rôle in the incidence of industrial disease. The question of immunity or the resistance to disease exhibited by different individuals has been known ever since the time of Hippocrates. The records of epidemics of infectious disease give ample proof of the variability of susceptibility in any given population, but it was not until the researches of Pasteur that the underlying factors related to susceptibility and immunity began to be understood. Pasteur's discovery of the microbe of anthrax and the study of its poison was the starting point of an enormous amount of research on the vital resistance of the body to microbial attack. Two schools rapidly grew up—the one which sought to show that the resistance to disease germs and poisons was a primary function of the body fluids, the other school, whose

chief exponent was Metchnikoff, maintaining that the destruction of living germs by the body, as well as the neutralisation of poisons which gain entrance to the body, was carried out through the agency of certain of the free and mobile body cells which were termed "phagocytes." Metchnikoff and his co-workers were able to show that invading germs were destroyed by the direct action of these white cells, and that they were enfolded by the substance of the phagocyte and finally digested in its interior. A further step given to the question of immunity was the discovery in the blood of animals which had survived a severe illness caused by a specific germ of a new substance not present before the attack of the disease; this new substance, which was termed "antitoxine," was found to neutralise the actual poison of the disease, and upon this discovery, through the work of Roux, Nocard, Bahrings and Ehrlich, the whole modern development of serum therapy in diphtheria, tetanus, cerebro-spinal fever and the like has grown up. The essential agents of the destruction of living germs and poisons are the white cells. Besredka* found that when the reddish-yellow granules of arsenic trisulphide were absorbed by the phagocytes the animals recovered from what was a fatal dose. But not only this: when soluble salts of arsenic were administered Besredka was able to show that the leucocytes contained far more arsenic than the blood itself. Moreover, it was further demonstrated that the resistance to toxic doses of arsenic was always greater in those animals in which the leucocyte reaction was prompt and efficient. Further, practically all poisons first of all provoke a diminution in the number of white cells, especially those known as the "chief phagocytes," and a similar condition is found with metallic poisons, such as lead, arsenic, and mercury. In T.N.T. poisoning there is also a tendency to a loss of white cells, especially phagocytes. Arsenic administered in medicinal doses increases the number of white cells; in poisonous amounts decreases them—in fact, it may be stated as a general law that diminished resistance to poisons, microbic and most metallic ones, is accompanied by a decrease in the total number of white cells in the blood, and especially those mainly concerned in phagocytosis. The importance of this I shall show later.

* Ann. de l'Inst. Pasteur, 1899, c. XIII., p. 49.

I have already said that all animals, including man, are found to differ individually in their resistance to disease and poisons; this immunity may be either natural or acquired. Natural immunity may be racial, generical, or individual, as may be its antithesis—natural susceptibility.

Acquired immunity may occur through natural channels, such as recovery from an attack of the disease; subsequent attacks of a similar disease are infrequent, and in many persons never recur, such as measles, diphtheria, typhoid fever, etc.

The reverse of natural immunity—natural susceptibility—is a factor of prime importance in the question of industrial diseases. Familiar examples of individual susceptibility are the rash following eating shellfish or strawberries, asthma caused by the emanation from horses, and the rash produced by handling certain woods and drugs. Just as immunity may be acquired by a susceptible animal, so susceptibility may be induced in resistant animals by appropriate means; thus, an animal may be rendered so susceptible to the action of simple white of egg that a small dose injected under the skin will cause the animal's death in a few moments. This condition is known as "anaphylaxis."

Industrial diseases in general naturally raise questions of (*a*) racial or individual immunity and susceptibility, and (*b*) acquired or active immunity and susceptibility. The question of passive immunity only belongs to treatment with serum of an immunised animal, with which I do not propose to deal. I have already pointed out that industrial diseases may be either primary or secondary. The Primary Industrial Diseases in which immunity and susceptibility play an important part are—

(1.) *Diseases due to Bacterial Infections.*—The chief is anthrax, but staphylococcal and streptococcal infections may also be classed as primary in certain instances.

(2.) *Diseases arising from actual contact of the hands or body with poisonous material*, examples of which are poisoning by T.N.T., various drugs, such as atropine, and the various forms of dermatitis due to handling drugs, sugar, etc., and some forms of cancer of the skin, at one time commonly known as "Chimney Sweep's Cancer," but now associated with the tar and pitch industries. Lead is not absorbed through the unbroken skin, although mercury may be.

(3) *Diseases arising from Dust, Fumes, and Vapours.*—To this class belong lead, arsenic, dope, and paint poisoning, etc.

Secondary Diseases.—The predisposition to certain diseases as an occupational accident is an extremely knotty point, more particularly as in many diseases occurring amongst industrial workers, other factors than those immediately associated with the specific occupation have as great, if not a greater action. It may be taken as a wide generalization that the true cause of secondary occupational disease is seldom the poison producing the specific primary disease associated with the industry. A good example of this is seen in the incidence of tuberculosis amongst potters. It has been frequently pointed out with considerable force and supported by reliable statistics that potters do, in fact, suffer from phthisis and other respiratory diseases to a greater extent than artisans of a similar age in the same population.* The primary disease of the china and earthenware industry is lead poisoning, and at first sight the figures would appear strongly to support the contention that lead poisoning predisposes to tuberculosis. It is found, however, that mining in the ganister mines is also associated with a high rate of tuberculosis, and the grinders of cutlery suffer from a disease known as "Grinder's Rot," mainly secondary tuberculosis. The one common factor to these three industries is dust composed of angular insoluble particles, but neither of the two latter are exposed to lead; moreover, in the systematic examination of three large lead factories during the last twenty years, the average total of persons employed numbering about five hundred, I have seen *no* case of tuberculosis, and yet the factor that all these workers are exposed to is lead dust inhalation—a good case might, therefore, be made out that the inhalation of lead dust is a protective against the development of tuberculosis of the lung! The fallacy is, however, only too obvious.

But it is to the primary disease associated with industrial processes that I wish particularly to draw your attention. Taking them in the order in which I have already enumerated them, anthrax comes first on the list. It is a disease due to infection with a microbe transmitted from animals to men and occurs in two forms (1) external, which is known as "Malignant Pustule," and (2) internal when it attacks the lung, as in Wool Sorter's Disease. Thanks to the activity of Dr. T. W. Legge, of the Home Office and the whole-hearted co-operation of manufacturers, this disease has undergone a great diminution, but it still is one of considerable importance; thus, in 1919, there were 54 cases, 8 of which were fatal. Table I. gives the age incidence of anthrax

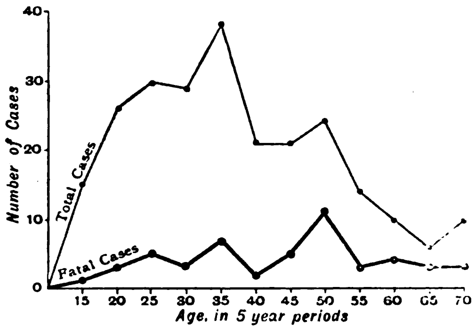

TABLE I. ANTHRAX.—This chart shows the proportion of Fatal Cases to Total Cases in 244 Cases, 50 of which were fatal, occurring in 1906, 1907, 1914, 1919.

for 244 cases, 50 of which were fatal. Figures are taken from the years 1906, 1907, 1914 1919, and they show that the fatality of the disease appears to be more marked between the ages of forty and fifty-five than between the ages of fifteen and thirty, though, no doubt, the number of occupied persons in these earlier years is greater than those in the second period. Nevertheless, the relationship of the fatality curve and the total curve shows that the younger persons employed would appear to be less susceptible than older persons. The disease—anthrax—is caused by the germ or bacillus of anthrax gaining entrance to the blood of an animal. In the presence of air and drying this microbe forms highly resisting seeds which are termed "spores"; these remain on the infective hides, wool, or horsehair, wherever blood has fallen. The spores germinate into the adult bacillus when they gain entrance to the animal body through skin or lungs and so come to affect wool sorters, dock porters, and tanners.

The second chart, Table II., shows the higher resistance of the younger persons, especially in the second of the two curves which are those not treated with serum. Serum treatment has apparently more

* Committee on Lead Poisoning in manufacture of Earthenware, Pottery, etc.—Appendices.

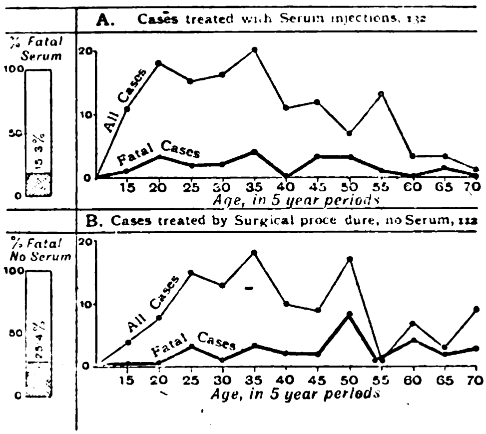

TABLE II. Showing Influence of Serum Treatment on Anthrax Mortality and Natural Immunity seen by the considerable recovery Rate.

ANTHRAX 244 Cases. Curves of Incidence and Fatality in Age Groups.

effect in advanced years than in early life. Now, anthrax immunity was shown by Metchnikoff and his co-workers to be related to the activity of the white blood cells already referred to in discussing immunity, and it is highly probable that the earlier resistance to anthrax may be bound up with the more active state of the phagocytes in the younger individual. Very great difficulty has been experienced in obtaining a good serum for the treatment of anthrax, although Pasteur long since proved that a susceptible animal may be easily immunised against a fatal dose of anthrax bacilli by inoculation, using the attenuated cultivation of the specific germ. The percentage of recoveries for serum-treated cases is only ten per cent. less than for the non-treated cases in this block of figures; none of the 112 cases in the second curve were treated with serum and yet 84 recovered through the agency of their unaided phagocytes; this fact, and the success of preventive inoculation against enteric fever leads one to hope that analogous measures could be applied to the prevention of anthrax in the wool trade.

Miner's "beat hand" and "beat knee" (acute inflammation under the callosities caused by the pick, etc.) are considered a primary industrial disease, although the microbial infection is that causing boils and blood poisoning in all classes of the general population. Some varieties of occupational dermatitis become secondarily infected by the same agents, generically known as the "pus cocci" (streptococci, staphylococci), while during the war persons operating capstan lathes and who were constantly splashed with the lubricating fluid used in cooling the tool, suffered from generalised pustular eruptions, but in all these instances only a limited number of those exposed to the risk develop the disease—man's normal resistance to this type of infection is high, but it is easily lost from the action of trivial complaints, such as enlarged tonsils or chronic constipation.

Diseases arising from personal contact with Poisons.—Poisoning in the manufacture of the explosive T.N.T. had never been regarded as an industrial disease prior to the war, in fact, Prosser White says of T.N.T. that "it is an innocuous, non-toxic substance which has never been known to produce illness." It is further stated that it was impossible to kill a single animal with the substance, although large doses were given.

When the first cases of T.N.T. poisoning were recognised the accumulated knowledge of poisoning in other industrial processes at once suggested dust as the cause; moreover, the complaint of an acrid taste by the employees appeared to corroborate the view. But exhaust ventilation failed to control the evil, and ultimately the poisoning was found to arise from absorption through the unbroken skin. The point was finally settled by volunteer workers, who performed their day's work in a diving dress supplied with fresh air from an untainted source; only the hands remaining exposed. The typical T.N.T. reaction was, nevertheless, found in their urine at the end of the day. Further experiments showed that a small quantity of T.N.T. rubbed into the hands of a susceptible person caused the typical reaction in the excreta without any symptoms of illness, but that those whose resistance was high did not absorb this minute quantity of poison.

This simple and safe method was thus applied to detect persons with a low resistance and enabled them to be excluded from the dangerous processes. Such a selection did not replace precautionary measures, but enormously reduced the cases of fatal illness.

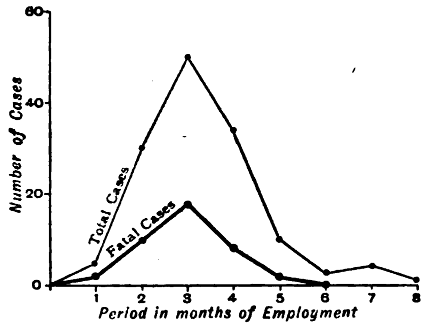

TABLE III.

T.N.T. Poisoning. Time of Onset and Fatal Cases according to number of months worked (Dr. Collis). Showing susceptibility to the poison.

Table III. from the paper by *Dr. E. L. Collis illustrates the early onset of T.N.T. poisoning and indicates the individual susceptibility to the poison.

Susceptibility to certain vegetable alkaloids, such, for instance, as atropine, is often extreme, as the following illustration shows: A worker in a drug factory developed the usual sign of belladonna rash, was suspended from work, and recovered; returned to the factory and was employed on bismuth oxide in another part of the building. Within three days he re-developed belladonna rash; he was again suspended, again recovered, and again returned to his employment, with a similar history. On the fourth occasion he made an application to the Medical Referee under the Workmen's Compensation Act and came before me. On enquiry I found that on each occasion he had resumed his work at the factory he put on his working clothes in which he first contracted the atropine rash and which had retained traces of the alkaloid, and that he had not worn these clothes between times.

Very little is known of individual susceptibility and immunity to many of the corrosive substances used in manufacture; thus, in the dyeing of yarn with chrome, certain persons exhibit ulceration after a very short time; others have a slight but recurrent dermatitis that only after long exposure degenerates into deep and penetrating ulcers. In this case natural immunity and susceptibility play leading parts in the appearance of the disease. Individual susceptibility explains many curious forms of ulceration seen in such trades as those of confectioners, drug manufacturers, manufacturers of felt hats and the fur trade, etc.; in not a few of these sufferers the susceptibility is due to a pre-existing skin disease of nervous origin (Chiro-pompholyx) which affects the palms of the hands. In the pitch industry and the handling of peat certain persons develop cancerous ulceration. Ulceration of the hands may follow from long-continued contact with tarry materials, but only a limited number of such cases degenerate into cancer.

Diseases arising from dust, fumes, and vapour comprise a large section of industrial disease, and amongst the air-borne diseases lead contributes by far the largest number of cases. Table IV. shows the

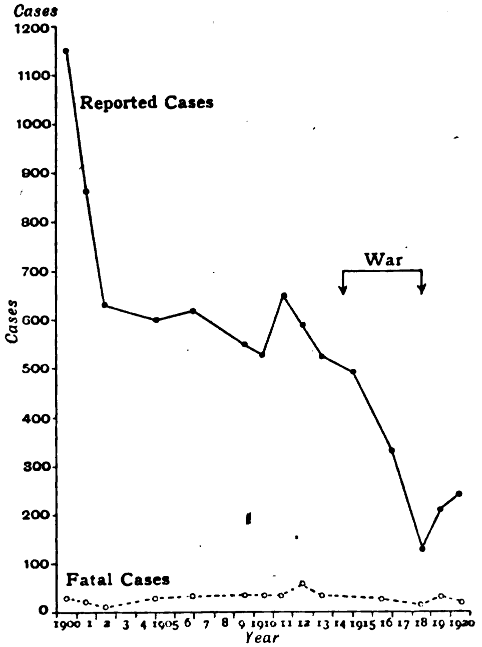

TABLE IV.

INDUSTRIAL LEAD POISONING—Reported cases and fatal cases, all industries, 1900-1920. Upper Curve. All Cases of Lead Poisoning. Lower Curve—Fatal Cases of Lead Poisoning. The great diminution in reported cases is shown in the upper curve and followed the enforcement of special precautions for dust removal, exhaust ventilation, etc. The curve of Fatal Cases remains level and may be taken to indicate the especially susceptible persons. Figures obtained from Reports of H.M. Chief Inspector of Factories.

incidence of all reported and fatal cases of lead poisoning from 1900 to 1920. It will be seen that the fall in the curve of

*Trans. Royal Soc. Med. 1917.

reported cases is very steep (the slight increase in 1911 is no doubt due to the activity in the motor industry). The lowest point is in 1918, at the termination of the war. There is a slight rise during the subsequent two years. On the other hand, the fatal cases show an almost steady line and may, I think, be taken as representing the extremely susceptible persons. I do not imply that the incidence of lead poisoning is only a question of individual susceptibility, but merely that the remarkable steadiness of the curve of fatal cases suggests that the population contains a considerable proportion who show individual susceptibility towards the poison.

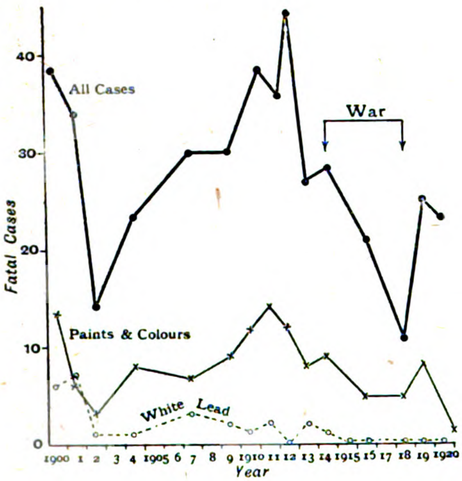

TABLE V.

LEAD POISONING FATAL CASES, 1900-1920.
Fatal cases of Lead Poisoning from all sources (compiled from the reports of H.M. Chief Inspector of Factories).
Upper Curve—Fatal cases from all sources.
Middle Curve—Fatal cases from Paints, Colours, Ship and Coach Building Trades.
Lower Curve—Fatal cases. White Lead manufacture.
The effect of regular medical supervision and the removal of the risks of poisoning by dust account for the fall in the white lead curve. There have been no fatal cases since 1915.

Table V. gives a comparison of the number of fatal cases reported from two industries compared with the total fatal cases in all industries (1900-1920). It will be seen that in the manufacture of white lead the diminution of fatal cases has dropped to zero in 1916, only three cases altogether having been reported since 1912, but in paint, coach and ship building, fatal cases form a somewhat large proportion of the total cases of all industries.

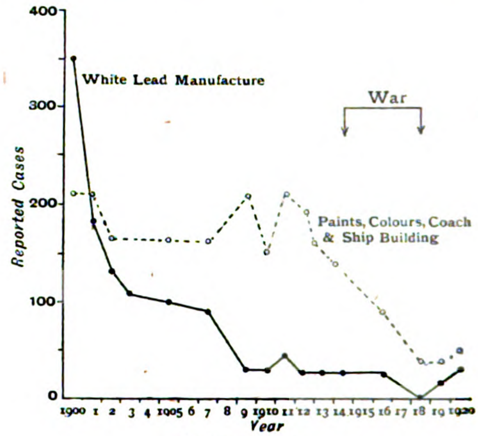

TABLE VI.

LEAD POISONING, 1900-1920.
Reported Cases (a) White Lead Manufacture.
(b) Paints, Colours, Coach and Ship Building.
Comparison curves between the number of reported cases in each year 1900-1920 in two industries.
Upper curve—White lead manufacture.
Lower curve—Paints, Colours, Coach and Ship Building.
Figures obtained from the Reports of H.M. Chief Inspector of Factories.

Table VI. is a comparison of the curves of reported cases (including fatal) in the manufacture of white lead, with those caused by paints, and colours. It will again be seen that the influence of the war had a striking effect upon the curve for paint and colours, but that the white lead curve was practically unaffected; we may conclude, therefore, that the cause of poisoning which was active in the paint, colour, coach and ship building industries was much less active in white lead manufacture. The curve in the white lead industry remains low from 1909 onwards; during this period special attention has been given to the elimination of dust. What, therefore, constitutes the factors causing the great difference between these two industries? It is impossible to obtain any reliable figures of the number of persons employed who are exposed to the risk of breathing lead dust in these occupations; the only reliable figures are the reported cases, and even in these considerable doubt may arise in diagnosis; thus, in the 1909 report of the Medical Inspector of Factories "ten

per cent. of the reported cases in the house-painting trade were rejected as unreliable.''

Another fallacy is the possible elimination of susceptible persons by the routine medical examination carried out under the special rules for white lead manufacture. This is probably balanced by the gradual tolerance developed by the majority of persons exposed to lead absorption; the evidence of such developed tolerance has been constantly brought to my attention both in the exercise of my duties as Specialist Medical Referee for Industrial Poisoning and in the inspection of certain large white lead and smelting works. In these works, at the termination of the war, a number of the old employees returned and were reinstated. These men had no signs of lead absorption when they were called up, although many of them had worked for long periods—some for fifteen years—in the white lead works. Within a few weeks of their return signs of lead absorption began to appear and a few cases of actual poisoning, but only mild colic, were reported. A careful readjustment of their work, including alternation of a dangerous with a non-dangerous process was adopted; the previous state of tolerance was soon re-established and now they show little or no sign of absorption, and no more cases of colic have occurred. Women who re-entered the local factories during the war showed no especial susceptibility to poisoning—and no increase of the returns of lead poisoning could be traced to their employment.

In order further to test the question of individual susceptibility and the development of immunity to lead I have tabulated the last ten years' records from my medical inspection cards of three factories and have plotted curves showing actual and potential disease according to the period of employment. All curves show a striking similarity, namely, that the occurrence of signs of lead absorption takes place within the first year, largely within the first three months of exposure. (Table VII.)

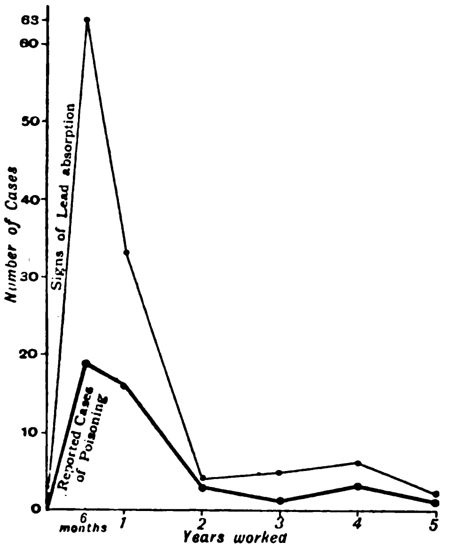

Table VII. Showing period of Development of Signs of Lead Absorption (Anæmia of Blueline).
1-5 years employment, 114.
Lead Poisoning (reported cases).
1-6 years' employment, 44.

1911-1921.

Combined curve of Figures from—

2 White Lead Works—Employed persons	342
1 Blue Lead Works—Ditto	278
1 Lead Smelting Works—Ditto	325
Total	1138
Total reported cases of Plumbism ...	52
Total Fatal ditto	0
Total Anæmia or Blueline (Absorption)...	126

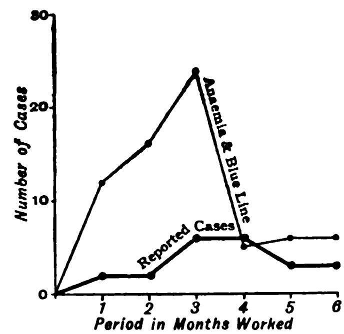

Table VIII.

1911-1921.

According to period worked before symptoms of absorption appearing in the case were diagnosed as lead poisoning.

In each chart the upper curve shows the number of individuals who exhibited signs of lead absorption without any definite symptoms of lead poisoning. The figures were obtained by extracting the reports in the medical registers of the factories.

The lower curve shows the actual reported cases of lead poisoning occurring in the same factories. The medical inspection of the factories is held on a certain day in each week, and a report of the individual's state of health recorded on his special card.

If these curves are compared with the curve of incidence of T.N.T. poisoning, Table III., a close similarity is observed.

In Table VIII., which is a combined curve of the three factories plotted in periods of one month, the sharp peak in the third month is most definitely shown. No fatal cases occurred during this period of 1911 to 1921; all the cases were mild and no permanent paralysis or disability remained. The lower curve represents the number of actual cases of lead poisoning, the upper curve the evidence of lead absorption. A considerable number of the men who were examined in 1911 are still working in the factories to-day. It follows, therefore, that these persons, especially those with temporary signs of lead absorption in the early period of their employment, have now established a state of tolerance or immunity to the poison. My chemical investigations into the elimination of lead from the body show that when tolerance is established any absorbed lead is discharged through the fæces and not, as has been often stated, through the kidneys.

Returning to the comparison of lead poisoning in the paint industry as compared with white lead manufacture, the high incidence in the painting trades is difficult to understand, as the risk of lead dust inhalation would, *a priori*, appear greater in the manufacture than in the use of lead as paint, as except in dry rubbing down, the painter is not exposed to lead dust. I have also proved that breathing lead dust into the lungs is the chief source of lead poisoning; all other causes are unimportant.

My own investigations into the action of turpentine on the animal body have clearly shown that the usual painter's colic— *i.e.*, the acute attack of abdominal pain so often contracted by breathing the air of newly painted rooms—is turpentine poisoning; many instances of this occur among painters. The affection is popularly attributed to lead poisoning and even an eminent scientist stated that the absorption bands produced by the vapour of drying paint were lead emanations which he considered must be so from the convincing and painful proof of an attack of painter's colic which he suffered during his experiments.*

Now, arterio-sclerosis, resulting in increased blood pressure, is admitted as a common disease among painters. In the report of the Commission on Occupational Diseases, Washington, the high blood pressure of painters is especially referred to, as it is in the article by Harris in the Departmental Health Committee of New York. Through the courtesy of Sir Lionel Earle I have been able to make a comparison of the blood pressures of painters (working with leadless paint for some years) with the blood pressure of workers engaged in the manufacture of white lead. This examination brings out an interesting fact. The white lead workers as a whole show a much lower blood pressure according to their age group or according to the period in which they have worked than do painters. This fact is shown clearly in Tables IX.,

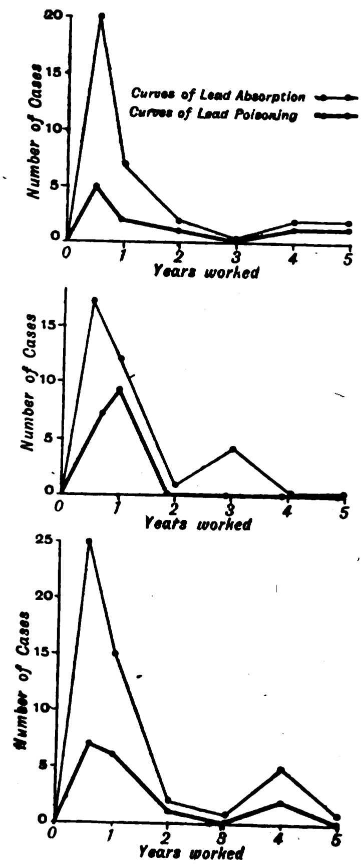

TABLE IX. Showing Development of signs of Lead Absorption in first six months of Employment, 1911-1921.

2 White Lead Factories—Persons employed	324
1 Smelting ditto—Ditto	325
Total	667

Figures obtained from weekly examinations. Upper curve signs of Lead Absorption, but no illness.

Lower Curve—Reported cases of Lead Poisoning.

* Prof. Baly. Minutes of Evidence, 17002. Committees on the Use of Lead in Painting [Cmd. 632.]

TABLE VIIIA. DETAILS OF FIGURES UPON WHICH THE CURVES ARE BASED.

LEAD WORKS, 1911 TO 1921.

	Employed.	Employed.	Cases Plumbism.		Cases Absorption.		Re-ported.	Poten-tial.
	1 year.	Less than 1 year.	One year.	Under one year.	One year.	Under one year.		
WHITE LEAD. Total employed 342	118	224	7	12	10	24	19	34
WHITE LEAD. Total employed	193		5	9	19	22	14	41
LEAD SMELTING Total employed 325	140	185	10	9	18	33	19	51
"BLUE LEAD" Lead Pipe and Lead Sheeting 278	222	56	0	0	7	0	0	7
Totals ..	$\underbrace{673 \quad 465}_{1138}$		22	30	54	79	52	133

TABLE XA

BLOOD PRESSURE IN WHITE LEAD WORKERS AND PAINTERS NOT EXPOSED TO LEAD DUST.

NORMAL BLOOD PRESSURE=AGE +100 IN M.M Hg.

Factory.	Total No. Exam.	Age 20-40 Group I.		Age 40-50 Group II.		Age 50-60. Group III.		Distribution All Groups.	
		B.P. above normal.	B.P. below normal.	B.P. above normal.	B.P. below normal.	B.P. above normal.	B.P. below normal.	B.P. above normal.	B.P. below normal.
WHITE LEAD I. ..	40	2	9	2	5	4	2	8	16
WHITE LEAD II. ..	50	4	25	4	7	1	3	9	35
PAINTERS, NO LEAD USED	45	4	2	2	9	12	8	18	19

White Lead Workers. Blood Pressure above normal = 18%
" " " below " = 56%
Painters no lead used. " above " = 40%
" " " below " = 42%

All workers had been employed for more than one year.

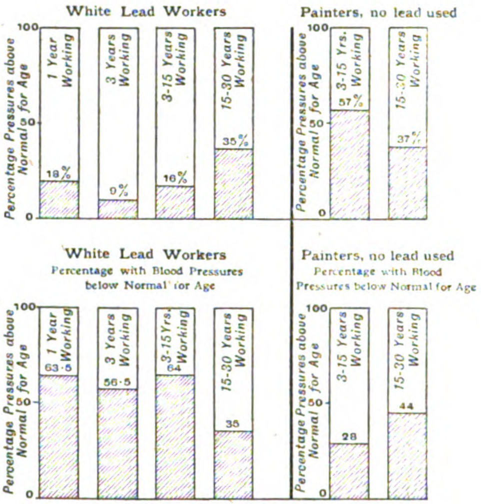

TABLE X.

Comparative percentage of Blood Pressures above and below normal for age in White Lead Workers and Painters not using Lead Paint, according to number of years employed. Blood Pressures calculated above and below normal for age.

Normal = Age—100 in mm. H9.

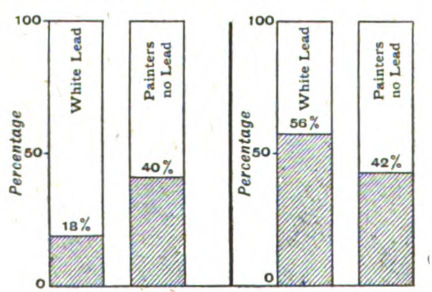

TABLE XI.

Percentage of White Lead Workers and Painters not using Lead Paint, which show Blood Pressures ABOVE and BELOW normal for age.

90 White Lead Workers. 45 Painters not using Lead Paint.

B.P. above normal for Age 20-60. B.P. below normal for Age 20-60.

X., and XI. The percentage of white lead workers suffering from raised arterial tension is only 18% of the total of 90 examined, their ages ranging from 20 to 60, whereas amongst painters of similar age distribution no less than 56% of those examined showed increased blood pressure, the normal pressure being taken as age plus 100 in millimeters of mercury.

The painter's occupation, therefore, apparently entails some other risk contributing to high blood pressure which is not present amongst the white lead workers. This may be readily seen to be associated with the vehicle in which the paint is used, the chief constituent of which is turpentine and its substitutes. In the experiments which were laid before the Committee on the Use of Paints Containing Lead,* etc., I was able to show that many symptoms which are complained of by painters may be produced in experimental animals (including myself) by inhalation of turpentine vapour; further, turpentine vapour is eliminated through the kidney, is an

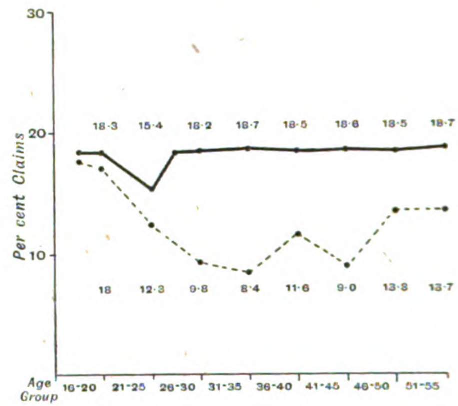

TABLE XII.

Percentage Sickness Claims 1919. Hearts of Oak Benefit Society, 2,013 Painters.—32,033 General Group in Age. Groups 16 to 55.

Upper Curve, General Group.
Lower Curve, Painters.

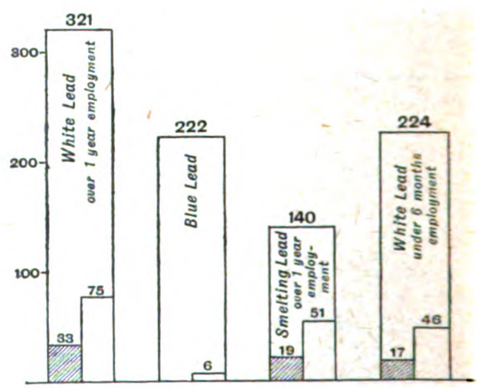

TABLE XIII.

Proportion of Reported Cases and Absorption in Four Lead Factories during 1911-1921. The columns are proportional to the number of men employed. Column 4 gives the proportion of cases of Absorption and reported cases in relation to the more casual part of the population in the two White Lead Factories.

* Goadby, Kenneth, 15914, etc. Committees on the Use of Lead in Painting.

irritant, and there is little doubt that the long-continued inhalation of this substance, even in small quantities, is attended with kidney changes and is possibly the cause of the heightened blood pressure and arterio-sclerosis so commonly associated with the painting trade. The series of 45 painters whom I had the opportunity of examining had used practically no lead paint and had done no dry rubbing down for many years.

Now, while it is certain that common ailments of the population at large may be augmented by industrial disease, it is equally true that industrial diseases are predisposed to by minor affections, especially the large category of small but persistent microbial poisons emanating from septic mouths, unhealthy tonsils, persistent catarrh and long-continued constipation, all and each of which sooner or later diminish the power of the blood to resist other poisons. These affections or minor diseases but rarely cause absence from work and do not, therefore figure as potential agents, neither is their presence an invariable indication *per se* of diminished resistance. The general medical examination of the population during the late war indicated an enormous number of unfit persons, and among the affections which contributed as many to the C3 category as any three other diseases was arterio-sclerosis, or premature degeneration of the blood vessels with an increase of blood pressure. At one time this affection was considered entirely a disease caused by the stress of hard work, and contributed to by alcohol and syphilis, but I have found increased blood pressure to arise from many forms of chronic poisoning of microbial origin, insidious and often unrecognised.

During my researches on the composition of the blood in various industrial and other diseases, two important points emerge :—

(1) In all chronic infections—that is, small and often unrecognised ailments of microbic origin—an alteration in the proportion of white blood cells may be detected (the alteration is mainly a decrease in the chief phagocytes) and usually occurs before the outward signs of ill health are manifest. This test is easy to apply.

(2) That a decrease in the white cells of the blood, especially when the decrease affects the chief phagocytes, goes with a diminished resistance to such poisons as lead, mercury, paint and the like. Such persons are especially susceptible to lead poisoning, etc.

My rapid survey of industrial disease indicates clearly the existence of individual susceptibility and immunity as factors determining much of the special disease in dangerous trades, and, moreover, suggests certain general blood tests, whereby susceptible persons can be eliminated from an occupation inimical to their well being. The blood tests I have referred to are simple and easy to carry out, while the estimation of blood pressure is an ordinary routine of medical practice and presents no difficulties. A selection of workers for especially dangerous processes following the general indications I have outlined, *e.g.*, alterations in their blood pressure and the white cells of the blood after a short exposure to the dangerous trade influences, would not only reduce the incidence of industrial poisoning in many occupations, but might even render safe some trades now regarded as dangerous, as I have shown may be accomplished in the white lead industry. Physiological tests are no innovation; even now colour blindness is a bar to engine driving on the railways; moreover, the great proportion of the work in dangerous trades is non-skilled work and is classed as "labouring," so that no hardship would arise from an elimination of susceptibles.

Industrial disease is undoubtedly a cause of unemployment, and, therefore, to decrease unemployment, not only should disease be prevented, but an attempt should be made to select for employment persons whose specific and individual powers of resistance are best suited for the particular type of employment. In any given industry the variations in employment, possible within the same industry, are very great and a judicious selection of persons for their employment would, no doubt, be a gain, not only to the individual himself, but to the industry as a whole. This side of problems of industrial disease is rarely given the consideration it deserves, but the mere prevention of the disease by striking out of an industry some special forms of poisonous, or partially poisonous, compound, may operate more hardly on persons eliminated from employment than it operates beneficially in protecting the fraction of susceptibles from risks.

Even in the painting trade the painter serves an apprenticeship, and during the earlier time is a labourer; two special examinations, one at three and one after six months' employment, would, in my opinion, be sufficient to eliminate sus-

ceptibles. The general principle of selection for a given occupation is carried out to some extent in many walks of life, and it does not seem unreasonable to extend the method, and I would commend a consideration of this point to the attention of those who have the well-being of the industrial worker at heart. Labour is, of course, represented on the various commissions and departmental committees which have investigated the origin and prevention of poisoning in various trades, but as far as I can gather, organised Labour or Trade Unionism as a body does not possess any especial organisation, department, or committee charged with the broad question of the health of its members; if such a body exists I have been unsuccessful in obtaining touch with it. The organisation possessed by Trades Unions could effect the most far-reaching enquiries into the actual health of its members, to a degree that no other organisation can possibly equal. The health committees already established in certain industries and factories have done some good, but, unfortunately, are not always encouraged by the Trades Unions. Where Whitley Councils have been established they have undoubtedly been of considerable advantage, both to the workers and to the employers, because they tend at once, by a closer intercommunication one with the other, to eliminate from the worker the feeling that the employer has no interest nor concern in the health of the employees, and the employer finds the workmen ready and willing to co-operate with him in methods for their mutual benefit. An instance of the salutary effect of the Whitley Council was brought to my attention only a short time since. I had occasion to make a recommendation that alternation of employment should be adopted in one of the lead factories to which I have already referred, on account of the increased susceptibility which many employees exhibited who had returned from active service. There was some demur in accepting the suggestion, which was that the employment should be so alternated that no man should be employed more than three days in the more insalubrious occupation. The Whitley Council discussed the question and notified me that if I considered it a matter of urgency they would put it into operation, which they did, and at the end of three months of the new regulations asked me for a report on the health of the men employed, as to whether it showed any improvement or not. Such is the ideal association for industry.

A Trades Union organisation charged with the general improvement of the health of its members, not with the provision of medicine for the sick, but with the conservation of its capital, health, would have the whole-hearted co-operation of the public at large and command universal attention, while it would find Capital anxious and willing to promote and strengthen the bond of community of interest which must ever unite the two great industrial forces—Capital and Labour.

DISCUSSION.

The Chairman (The Right Hon. J. R. Clynes) said it had been remarked that there would be something appropriate in one who was associated with organised labour taking the Chair at that meeting. Whether there was anything appropriate in it or not, he could say that he had derived very considerable profit from what the author had said, and he felt it an honour to be associated with Sir Kenneth in such an important public service as that in which he was engaged. He understood from the author that certain of the principles to which he had addressed himself had been known since the time of Hippocrates, and he would suggest that the application of those principles must have travelled very slowly in the interval, and that anything that could be done to speed up their application would be of enormous benefit to millions of the wage earners of this country. It was clear from what the author had said that the men and women of this country who were called to pursuits of science and medicine had still very many wide fields to cover. The facts of human nature would always afford a field for exploration. That field, he believed, had been neglected to a great extent during the era of industrial development covering the last ninety years. It was true that progress had been very considerable in the last 25 or 30 years, thanks very much, for instance, to such stimulation as the Home Office and men like Dr. Legge had given to employers of labour and to workers alike in the factories and workshops of the country. The interests of a great industrial Kingdom such as Great Britain were entitled to the aid and resources of science and medicine so far as that aid could be given. Those who applied themselves to the work must not expect much public reward or acknowledgment or thanks for it; it was unheroic work; it would not fill the newspapers and it would bring very few testimonials, but it was work which was supremely important to the health and even to the industrial efficiency of

millions of workers. If for no other reason than the business reason, employers of labour might very well show some advance upon that degree of enlightenment which many of them had manifested in regard to the physical and health conditions of the workers during the last fifteen to twenty-five years. He had to admit the charge implied in what the author had stated, that as yet the great Trade Unions had not established any kind of organisation as a branch of their service, covering the wide field of the health of the workers. The truth was that for a hundred years Trade Unions limited themselves to providing monetary benefit to relieve sickness. Now the stage had been reached where clearly it would be better for Trade Unions to do something to prevent sickness rather than to alleviate it. The establishment of the Joint Industrial Councils, commonly known as the Whitley Councils had provoked a good deal of controversy, and of late there had been differences amongst those who formed those Councils on questions of wages, working conditions, hours of labour, proposed reductions and other matters of a purely industrial character. He had the honour to be one of the Committee which, under the Presidency of the present speaker of the House, Mr. Whitley, called the Whitley Councils into existence, and he could, therefore, say that as yet they had not approached a few of the more important branches of the service for which they were intended. He did not blame them for that, for the fact was that in the few years during which they had been in existence, they had been almost distracted by endless conflicts on wage questions, and he supposed that if any Joint Industrial Council were called to-day, the matter that would be uppermost in the minds of those who attended the meeting, would be a wage question. He could only express the hope that before long those Councils would emerge from all those distractions and would be able to find time to take in hand many other most important matters of joint interest and mutual benefit both to employers and to employed. It was not merely a joint interest, but a matter of national importance. The war might have altered many things in this country, but it had left unchanged the fact that the country was a great manufacturing and exporting community. As an industrial nation the country had a supreme interest in developing and popularising questions relating to the health of the workers in all trades and industries. The industries were activities expressing themselves more and more in the direction of human life, and workmen were not merely producers of wealth, but fathers and citizens and, therefore, ought to be interested and made to be interested in the problems dealt with in the most illuminating paper that had been read that evening. The country had not yet overcome one of its greatest enemies, ignorance, but science and medicine were assisting in that direction. The human side, which was now finding expression in the workshop and to which all employers of labour must more or less pay respect, was a side which would render great public service if developed. He could not promise that Parliament at once would spring to its feet in response to any invitation to deal with the question, so that it would mean very hard work for those who had such an unpopular but essential pursuit to follow. At the same time he thought it could be said that it was a matter upon which Parliament could be led the right way, and, while it could only be hoped to create a great volume of popular opinion in support of any view such as that put forward by the author, he trusted that the facts that had found expression in the paper would go far to guide those who were responsible in connection with great questions of public health. On behalf of the meeting he expressed his wholehearted thanks to the author for the trouble he had taken in writing the paper and for the service he had rendered by doing so.

DR. T. M. LEGGE (Medical Inspector of Factories) said that a well known Trade Union leader wrote to him once having the temerity to call in question the views of a person described as "a certain Dr. Goadby," and he (Dr. Legge) had great pleasure in writing back to say that he thought Dr. Goadby had brought one of the freshest and most original of the younger minds in medicine to the study of industrial questions. He thought the audience would agree with him that that freshness still remained. The point that had struck him most was the extraordinary variability in connection with the use of the word "prevention." The words "preventive medicine" were used very loosely. Public health, in spite of its claims, did little more than try to minimise the effects of diseases. Although that was a great aim, it was not so great as that of eradicating disease altogether. The gift of prevention, like Pentecostal fire, fell on the head of the chemist and of the engineer in greater measure than on that of the medical man. It was a pleasure to factory inspectors to feel that their work as hodmen in medicine, collecting data, had led to the cream being taken off by the beautiful work of such scientists as the author. With regard to anthrax, although the author had said a diminution had been brought about, he was afraid that was not exactly the case. Taking the figures for anthrax during the last twenty years, in 5-year periods, it would be found that, instead of diminishing, the disease had increased within the last five years, compared with what it was twenty years ago. The reason for that was that an attempt had been made to treat the effects and not to get at the cause. The one thing that it had been possible to do

was to make use of that power of acquired immunity and stimulate the blood cells in such a way that they could kill the bacillus, when it gained access, by the modern treatment with serum. The deaths had been stopped, but cases had gone on increasing. In Liverpool there had been erected at the cost of the Government, a disinfecting station, which destroyed the anthrax bacillus, and in the course of years the nightmare of anthrax would be removed from Yorkshire. That had been due to the work of a chemist, Mr. G. A. Duckering. He would like to ask the author whether he did not consider immunity and stimulation of the white blood cells as being the essential agent in immunity. In anthrax he recognised the difference between animals but found it difficult to recognise a difference in immunity in different factory operatives. He knew a factory in Bradford where the most dangerous material was manipulated, and that factory, unfortunately, had the largest number of cases and deaths. In his experience it was the looseness of the cellular tissue which determined the severity and frequency of anthrax. He had never known a case of anthrax on the palm of the hand, although that was the part that came most frequently into contact with the anthrax material; the thickness and nature of the skin of the hand prevented the bacilli getting through. On the other hand, if the bacillus got into a short thick fat neck it had an open field for its multiplication. He could support the author in another aspect of acquired immunity. One of the most troublesome conditions the Inspectors had had to deal with had been industrial eczemas. Several years ago they used to be much perturbed at the outbreaks of industrial ezcema, yet an attitude of masterly inactivity proved extraordinarily successful, through an acquired immunity which led in many cases to the patients being completely cured. With reference to the help that Trade Unions and labour organisations could give, he could remember, when a member of the Committee on Compensation for Industrial Disease, three cases which were striking instances of that help. An almost blind Secretary of a glass bottle works came before the Committee. He had taken a particular interest in the effects of glass blowing on the workpeople, and had noticed how many of the workpeople came on the superannuation list because of cataract, and he produced case after case of cataract in glass workers. Enquiries were made and it was proved beyond doubt that there was a distinct form of cataract amongst glass blowers. That led to the wonderful work of Sir William Crookes, who took up the matter, and worked at producing glasses which cut off the heat rays. The disease was scheduled largely on account of the work of that blind Trade Union leader, Mr. Greenwood. Then Mr. Wignall, the member of Parliament for the Forest of Dean, described the effect of pitch and tar on the workers who were making patent fuel in South Wales, and that disease was scheduled. The patent fuel workers, unfortunately, had a suspicion in their minds that the knowledge gained from medical examination was going to tell against them, and that stood in the way of giving them successful assistance. He remembered the time when, metaphorically speaking, a chunk of boxwood was thrown by a Trade Union official at the head of a professor of botany in Liverpool, and that professor extracted out of that piece of boxwood an alkaloid which he believed detrimentally affected the health of the workers.

Professor H. E. Armstrong, F.R.S., urged the importance of putting the words "lead poisoning" into inverted commas, because in the great majority of cases he believed it was not known that they were due to lead poisoning. Up to about ten years ago, whenever a painter complained of anything he was said to be suffering from lead poisoning. Then the author and others were led to recognise that in the great number of cases it was not lead poisoning at all but the effect of the turpentine or other medium used in thinning the paint. He believed that if many of the curves that had been shown were analysed it would have to be recognised that they were dealing with a complex of factors and not with a single factor. It was necessary to be very careful indeed before coming to definite conclusions on any of the points with regard to the cause. With reference to T.N.T. poisoning, it should be remembered that no T.N.T. was manufactured in this country, practically speaking, before the war—it was not known how it could be manufactured. One man did make some of it for the Bulgarians or Serbians, but no experience had been obtained with regard to its effect. The strange thing was that the medical profession had taken no notice whatever of what was known of the necessarily poisonous effect of such substances. In the early months of the war a considerable number of fatal cases occurred from the inhalation of vapours in the factories where people were engaged in varnishing aeroplanes. Solvents were used known to chemists as poisons; but not recognised by the medical profession as poisons. It took a long time for knowledge of such points to permeate the different professions. With reference to the question of susceptibility, he ventured to suggest to the author that he should widen his enquiry. The projected methods of examining everybody for everything before they were allowed to do anything were becoming rather terrible. The psycho-analysts were trying to tell people whether they were fit for this or that employment, and now it was suggested that people should have their blood

pressure taken; that sort of thing was continually suggested. What ought to be looked to in the case of all workpeople was the character of their feeding, because he believed that lay at the root of much of what was called susceptibility. It was beginning to be realised that the masses were not fed properly from the point of view of quality, not so much from the point of view of quantity; and it had begun to be recognised that an enormous value resided in uncooked vegetable food. Clear evidence on that point might be obtained in a book published quite recently by Col. MacCarrison, which gave an extraordinary mass of information on the question of deficiency diseases. The bad teeth of the nation could be traced in the main to faulty feeding in early youth. If, instead of directing attention to the minor points, attention were directed to a proper milk supply for the country, it would probably do very much more to make the masses less susceptible to disease than anything else. The paper was of great value in calling attention to many important matters and in providing a basis on which discussion could take place.

The Chairman asked permission to leave the meeting to attend to his duties in the House of Commons, and the Chair was taken by Dr. Legge.

Dr. E. Halford Ross said that when a leader of the Labour Party in the House of Commons could come to the Royal Society of Arts to preside over a discussion on health in industry, he did not think it could be said there was an absence of interest taken by the Trade Union organisations in the subject. Last autumn he had written to the *Times* a series of letters describing certain definite bodies contained in dust which produced printer's phthisis, and as a result of that letter the Joint Industrial Council of the printers' trade had taken up the matter very strongly, and at the Printing Exhibition recently the Health Committee investigated the whole matter and came to the conclusion that the way to prevent this disease was by having cleanliness in printing works. It was the tiny fibres from the paper that carried grit into the workers' lungs in the composing room. A very large printing works was set up in the early part of the war in a crowded London suburb, and owing to the peculiarity of the printing it had been possible to do away with the composing room altogether. The printing was done by photography, and instead of having a stuffy composing room there was really a spacious photographic studio where grit did not exist. There was no wood pulp paper used, because the paper that had to be worked with was made of flax, which had a fibre that did not float about in a room. Among 700 people working in that printing works for five years there had not been a single case of consumption. With that evidence in front of them, the Joint Industrial Council thought it was time something was done in other directions, and were going to have vacuum cleaners placed everywhere. The Bank of England had spent a considerable sum of money on vacuum cleaners in their works, so that all the dirt and dust could be drawn into the basement. Many other works were making experiments, especially the St. Clement's Press, which was organising experiments by which the compositor could put the trays of type into a box in which there was also a vacuum cleaner and the whole thing was cleaned up. Another firm was using the nozzle of a vacuum cleaner, bent at right angles, to go over the type boxes and suck out the dirt. Trade Unions, firms and Joint Councils were doing whatever they possibly could to prevent disease. The coal strike had given opportunites for investigation, because as a result of the strike visibility had considerably improved in London. London smoke consisted of fibre which was derived from the refuse of the trees, vegetable refuse meshed in the coal. When coal was burned a great deal of the fibre was unconsumed and escaped into the air. At most times of the year the smoke was blown away by the prevailing south-west wind, but sometimes with an anticyclone there was a condition of still high pressure, which caused the smoke to hang over cities. It had now been discovered by the Medical Correspondent of the *Times* that colds during the coal strike had greatly diminished. As a result of that he was convinced that the fibre he had spoken of was the carrier of the grit in printer's phthisis.

Dr. S. Miall said he had found the paper and the discussion full of interest even to one like himself who had only an amateur knowledge of such matters. It seemed to be the universal opinion that we were surrounded by a mass of deadly enemies, germs, poisonous fibres, and other weird things, and that the two opportunities open to us to escape were first of all to get rid of as many of such extraneous matters as possible, and secondly to feed ourselves well and keep in good condition. The seeds of disease and the seed of industrial poisons were so prevalent that they could hardly be escaped, but if people took care to have a healthy soil, in which such germs and poisons could not grow, they would escape. The diagrams that the author had shown were of great interest and would well repay careful study. He was sure the meeting was very grateful to the author for the extremely interesting set of facts he had given them to ponder over.

Mr. Peter Pickles said that, as one who had had over thirty years' experience in the painting trade, he would like to have some advice on certain points. The author, in quoting

figures based upon the returns published by the Hearts of Oak Society on the health of painters as compared with other people, had led him to believe that painters were rather insurable persons because of their good health. Dr. Legge, in giving evidence before the White Lead Commission, took certain figures furnished by the painters' organisation and said that in accordance with those figures painters lived eight years less than persons in other industries. He wished the author and Dr. Legge would agree with one another and give the real facts. Was it to be understood that men died because they were so healthy or what was wrong with the doctor? The author had shown how unreliable the opinion of a doctor was, and especially that all the time the doctors were dealing with white lead they should have been dealing with turpentine as the cause of certain industrial diseases. He thought painters were really justified in saying that they did not believe the doctors when they furnished figures about them which they knew were contrary to their own experience. What would be the first advice given to him as a painter when, supposed to be suffering from white lead poisoning, he came before a doctor? The advice given would be to get outside the trade as soon as possible, and if he was a wise man he should do so, provided he could find enployment. Then he would cease to be a painter, because he had lost vigour through lead poisoning, but fifteen years later, when he died, he would not be described as a painter dying of white lead poisoning. If doctors could not tell the difference between arterio-sclerosis caused by turpentine and symptoms of white lead poisoning, then how could they diagnose any disease? It was said by doctors that a man was suffering from white lead poisoning because he had a blue line on his gums, and the question naturally occurred: Did he have a blue line on his gums when suffering from turpentine? Painters feared being examined for certain diseases, because if they were found to be suffering from lead poisoning they got the sack and were out of work, and consequently they sought to hide the fact that they were suffering from any particular disease. The painter's position was like that of a parson: the parson said he would not temporise with the devil and the painter said he would not spend his time and his money to abolish the evil of white lead, as his mind was made up that there was no need for white lead in the trade. Speaking from thirty years' experience of all those things, he could say that painters were not to be blamed for not finding remedies for certain diseases when they felt that the work should be devoted to getting rid of the cause of such disease.

Mr. R. Crosley asked whether America was very much in advance of Great Britain in connection with industrial diseases and whether they employed their own doctors.

Mr. H. Cope West said that since the enquiry into the use of white lead paints a good deal more had been learned, and the expectation of life of all sorts of persons had been calculated for a good many occupations. Taking the painter at ages 25, 35, 45 and 50, the "Expectations of Life" came out at 36.4, 28.2, 21.2, and 15.2 years and for "All Males," 37.3, 29.5, 22.3, and 15.8 years. The difference was only a year in any case. The occupational death rate was a thing everyone wished to prevent, but no one would mind in the course of occupation removing from London to Liverpool, although the difference between London and Liverpool was 5 points, a difference of over 30 per cent.; deaths attributed to lead poisoning were only one-fifth of one point. Taking the comparative mortality figures it would be necessary to go very far down the list of occupations to find a difference of 30 per cent. The difference between painters and the average of "All Males" on the 1901 figure was 1,041 against 1,000 for "All Males"—only 4 per cent higher.

Sir Kenneth Goadby, in reply, said he was extremely gratified at the discussion that had taken place. With regard to the Whitley Councils, Mr. Clynes had admitted the grave difficulty that Dr. Legge also noted of obstacles that were met with in attempting to diminish industrial disease. Knowledge was common property, and if any forces were working contrary to knowledge and truth sooner or later they must be discredited, no matter how hidden. Doctors were trying to get at the cause of industrial disease and desired to find the best method of preventing those diseases, and in many cases, where it was impossible to do away entirely with industrial disease, they desired to modify its severity. Every occupation had its mortality, even the medical profession. During the last five or six years four of his own friends had died through the effects of X-ray work, which was an industrial risk, and he had lost three or four friends through glanders, anthrax and blood poisoning, which were all industrial diseases to the medical profession. There were always difficulties in the way of prevention of disease. Workmen would contravene rules which were made for their own benefit, and some of them even had to be summoned for disregarding them. Was it to be wondered that occasionally medical men were angry with crass stupidity of that description? The minute differences between various types of industrial disease, especially lead poisoning and turpentine poisoning, were extraordinary. He knew of a man who was stippling glass with zinc paint, and, owing to the position of the glass, he had to work close up under it in hot weather for three days. During this work he inhaled the turpentine and had all the symptoms of lead colic, and he was reported as a case of lead poisoning.

Dr. Legge said that lead poisoning in house painters was not notifiable.

Sir Kenneth Goadby said the question of phthisis amongst painters was of interest in view of the inhalation of volatile vapours. Last year he had the opportunity of seeing certain methods in operation in the State of New York, where they had established what were called travelling clinics—and he thought they might well be established here—for the examination and treatment of industrial disease. The clinic was composed of specialists on various diseases, two or three nurses, and a mobile X-ray laboratory and a pathological laboratory. When it was decided that a certain district should be visited by the clinic, they notified the various doctors, including the factory doctors, that they were coming and asked for patients to be brought forward. The pathological and X-ray laboratories were sent down in advance, and examinations were made of the cases. A week later, when the clinic arrived, the cases were seen by the specialists and the local doctors were advised as to the best lines of treatment. The clinic did not carry out any treatment itself. This placed the health authorities in possession of all sorts of statistics which enabled them to deal with certain diseases as a whole, and it gave the local doctors the advantage of consultations with experts in various subjects and on various types of diseases.

A vote of thanks was accorded to Sir Kenneth Goadby for his paper, and a vote of thanks to the Chairman concluded the meeting.

CORRESPONDENCE.

X-RAY MOTOR AMBULANCES.

I had the opportunity, afforded me by the receipt of the *Journal* of May 13th, of bringing before a leading member of the medical staff of the Canada Department of Soldiers' Civil Re-establishment, whose headquarters are in this city (Ottawa), the excellent paper by Sir James Cantlie, on "An X-Ray Motor Ambulance Wagon for use in Civil Life at Home and in Tropical Countries." He was much interested and thought that every support should be given to the proposal in the United Kingdom, from which he had only recently returned and where he had seen a good deal of hospital service during the war. "But," he said, "no such system need be adopted in Canada, as here and in the United States the Coolidge Portable X-Ray Equipment is used, which can be packed in two hand-bags and easily carried to the bedside of any patient, such as those described in Sir James Cantlie's paper, who cannot be removed without danger to any local hospital or X-ray establishment." The cost of this equipment, he stated, is only £100 or thereabouts, and its efficiency has been fully proved. "But," my friend continued, "the use of that method is rendered possible by the fact that Canada and the States almost universally use electricity of uniform voltage (110), which renders it easy to obtain the force required from the nearest electric plant, which may be in the same house or in the immediate neighbourhood."

The question naturally arises: Would it not be possible for England to adopt a uniform voltage, not only, it may be argued, in the interests of X-ray patients, but for its general use? This, of course, is a wide question, on which much useful information may be obtained from this country, according to the opinion of my medical friend.

E. T. Scammell.

PHONOSCRIPT.

On page 491 of the *Journal* of June 17th, it is stated that "To class (*b*) belong Miss A. D. Butcher's Orthotype . . . and many of the popular dictionaries."

As this statement might mislead your readers, will you allow me to call their attention to the fact that if the real shorthand characters of the Orthotype notation had anything in common with the diacritical notations of dictionaries, then Orthotype, which is a feasible method of "Printing Reform" for all languages, could not have been patented as it was in 1907.

The seven vowel signs used in the script and print patented, do not *distinguish* the vowel letters a, e, i, o, u, w, y, but, on the contrary, they *extinguish* them with all their irregular combinations whenever these are calculated to mislead the reader.

The Roman type is not adequate to express any language, and until it is standardised, there is little hope that Mr. Maclean's prophecy will be fulfilled, and the people of the world be able to understand and read English.

Before adding new letters to the Roman alphabet it would be as well to see the result of former experiments in other languages than English.

The Greeks found it necessary (B.C. 403) to add the vowel letters Eta, η, and Omega, ω, to denote the long ēē and oh sounds. At the present day while the printer still uses these letters, the Greek pronounces the Omega exactly like the Omicron and the letter Eta, η, just as he does the Iota, ι, and the Upsilon, υ.

This is an example of the natural phonetic decay to which all language is subject consequent on rapid speaking, and Sir Robert Bridges has pointed out how this decay is hastened by the phonetic printing of the unaccented neutral vowel sounds, thereby rendering permanent what is only a passing phase of mis-pronunciation of sounds which do not affect the meanings of isolated words.

Spelling is best taught by pedantic and clear articulation, in short, by reforming the print and then pronouncing a language as it is printed, instead of printing it as it is pronounced.

If the great book of "human misunderstanding" is studied, it will be found that ninety per cent. of mistakes arise from misplaced accent or stress, and the remaining ten per cent. from the neglect of the prolongation of the long diphthong sounds which form the chief characteristic and the especial beauty of the English tongue.

A legible print then should attract the eye to the loudest syllable of the word, giving its correct pronunciation at the same time.

A. DEANE BUTCHER.

PAPER-PULP SUPPLIES FROM INDIA.

I venture to send a few remarks on Mr. Raitt's valuable paper on "Paper-pulp supplies of India," which may be of interest as indicating another direction in which India may contribute a not inconsiderable quota to the much-needed supplies of raw material for papermaking.

For more than thirty years past it has been recognised in scientific circles that the short fibres retained by cotton-seed after ginning constitute an excellent r w material for the manufacture of paper and of other cellulose derivatives, but the removal of these fibres from the seed in a merchantable condition was found to be a very difficult mechanical problem which has only recently been satisfactorily solved. I can, from experience, endorse Mr. Raitt's view that nature guards her secrets very closely and those who seek to wrest her secrets from her must be endowed with great zeal and great patience. I dealt with the general subject at some length in a paper published in the *Journal* of February 14th, 1919, and need, therefore, only refer here to what appears to me an important bearing of the utilisation of these residual fibres, in combination with the projected development of bamboo-pulp, upon the paper-making industry of India.

Last year a British Company was formed for the development in England and elsewhere of the special machinery by which these residual fibres are removed from the cotton-seed without injury either to the seed or the fibre. Arrangements are in progress for the establishment of plants of these machines in the United States. Similar plants are contemplated in South America, Italy and China, and it is hoped that by the end of this year an Indian Company will be launched for the defibration of cotton-seed in India on a large scale. Space does not permit of my going into much detail, but it may be mentioned that an average cottonseed crop in India contains from 50,000 to 80,000 (or more) tons of residual fibres which, at present, are not only wasted, but are actually detrimental to the seed for the purposes for which it is employed, namely, for feeding cattle and for the manufacture of cotton-seed oil.

Mr. Raitt rightly says that paper cannot be usefully made from mechanical wood pulp alone. I do not gather whether he claims that bamboo-pulp will be the equivalent of—or at least similar in its characteristics to—sulphite wood pulp. Very few papers are made exclusively of any one raw material, the finish usually consisting of mixtures in varying proportions of rags, sulphite, esparto and the like. The residual cottonseed fibres have been found to blend very well with sulphite and esparto and other materials, and there would not appear to be any reason, *a priori*, why they should not blend equally well with bamboo-pulp prepared in the manner indicated by Mr. Raitt. In such case India should, in the near future, be in a position to provide at least a substantial proportion of her domestic requirements of fine writing and printing paper, which should be an important consideration in view of the scarcity in India of suitable raw materials for the manufacture of high grade white paper which necessitates the importation of a very large proportion of the paper consumed in India.

E. C. DE SEGUNDO.

OBITUARY.

THOMAS L. F. ARMITAGE, M.D.—Dr. Thomas L. F. Armitage, who was elected a Fellow of the Royal Society of Arts in 1910, died at Princeton, Minnesota, U.S.A., on June 3rd, after a short illness. Born in Ireland in 1860, he was educated at the Royal University of Ireland and the Queen's University of Belfast. He entered the Army Medical Corps and served through the Soudan campaigns of 1885 and 1887, winning the medal and bar and the Khedive bronze star.

In 1898 he proceeded to the United States and settled in Princeton, of which he became Mayor. He was, naturally, an ardent supporter of the cause of the Allies, and when America decided to join them he took a prominent part in promoting war activities in his adopted town.

GENERAL NOTE.

BRITISH CAST IRON RESEARCH ASSOCIATIONS.—A license, under Section 20 of the Companies' (Consolidation) Act, 1908, has been issued by the Board of Trade to the British Cast Iron Research Association, which has been approved by the Department of Scientific and Industrial Research as complying with the conditions laid down in the Government Scheme for the encouragement of industrial research. The Secretary of this Association is Mr. Thomas Vickers, Central House, New Street, Birmingham.

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FRIDAY, JULY 8, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

EXTRA MEETING.

An EXTRA MEETING will be held on THURSDAY, JULY 14th, at 8 p.m., when a paper on "Paints, Painting and Painters, with reference to Technical Problems and to Public Interests" will be read by PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., and MR. A. C. KLEIN.

PROCEEDINGS OF THE SOCIETY.

ANNUAL GENERAL MEETING.

The One Hundred and Sixty-seventh Annual General Meeting for receiving the Report of the Council, and the Treasurers' Statement of Receipts and Payments during the past year, and also for the Election of Officers and New Fellows, was held in accordance with the By-laws on Wednesday, June 29th, at 4 p.m., MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

The Secretary read the notice convening the meeting, and the Minutes of the last Annual General Meeting held on June 30th, 1920.

The following candidates were proposed, balloted for, and duly elected Fellows of the Society:—

Afzal, The Nowabzada Khwája Muhammad, Khan Bahadur, M.L.C., The Palace, Dacca, India.
Anderson, Sir Arthur Robert, C.B.E., C.I.E., Assoc.M.Inst.C.E., London.
Cadbury, Major Egbert, Bristol.
Coutts, William Scott, Kuala Lumpur, Selangor, Federated Malay States.
Dalpatbhai, Jagabhai, Ahmedabad, India.
Daunt, Hubert Edward, Kobe, Japan.
Dawson, Captain Francis Murray, M.C., B.Sc., Toronto, Canada.
Halliday, Edgar Charles, London.
Harrison, Frank, M.I.Mech.E., Bickley.
Hart, Frederick A., San Fernando de Apure, Venezuela.
Hudson, Mrs. Mabel Juliette, Derby.
Huggins, George Frederick, O.B.E., Port of Spain, Trinidad, B.W. Indies.
King, Daniel T., Great Yarmouth.
Lawford, Captain Philip Guy, Ipoh, Perak, F.M.S.
Lines, Alfred W., Pernambuco, Brazil.
Macdonald, Miss Emily Flora, London.
Masters, Edward Godfrey, Shantung, China.
Morgan, J. T., Cardiff.
Park, James Robert, LL.B., London.
Parker, Miss Gladys Muriel, London.
Price, Cyril, New York City, U.S.A.
Pugh, Colonel A. J., O.B.E., V.D., M.L.C., Calcutta, India.
Raisurana, M. C., Calcutta, India.
Ricou, C. E. W., Macao, China.
Roy, Rai Sahib Krishna Lal, Calcutta, India.
Teo Yee Swee, Swatow, China.
Thakardas, Purshotamdas, C.I.E., London.
Webber, Miss Gladys Mary, London.
Wilson, P. R., London.

The Chairman appointed Mr. Julius Garratt and Mr. J. G. W. James scrutineers, and declared the ballot open.

The SECRETARY then read the following—

REPORT OF COUNCIL.

I.—H.R.H. THE PRINCE OF WALES VICE-PATRON OF THE SOCIETY.

The Council have the honour to report that His Royal Highness the Prince of Wales, K.G., has accepted the office of Vice-Patron of the Society.

The warm interest taken by the Royal family in the Society's work has now continued over a long period. The Prince Consort was elected President in 1843, and took a leading part in directing the activities of the Society until his death in 1861. In 1863 the Prince of Wales (King Edward VII) succeeded him and held the Presidency until 1901, when, on his accession to the Throne, he became Patron. He again

was succeeded by his son, King George V., who is now Patron of the Society, His Royal Highness the Duke of Connaught and Strathearn, having succeeded him as President in 1911.

II.—ORDINARY MEETINGS.

Mr. Alan A. Campbell Swinton, who had already acted as Chairman of the Council for the years 1918-20, was re-elected in 1921 for a further term of office. During his first tenure of the post he delivered two inaugural addresses on general subjects. This session he elected to give an address illustrated by experiments, and he chose as his subject "Wireless Telegraphy and Telephony." After describing some of the most recent inventions in wireless telegraphy, he gave a demonstration of the Creed Printer and Receiver, an instrument invented by Mr. F. G. Creed, of Croydon, which has recently been adapted to receive wireless messages, and to print them in Roman characters. This was the first occasion on which the instrument had been exhibited in public, and it was remarkably successful in receiving and automatically printing a message despatched from the Eiffel Tower to the meeting. The Chairman also succeeded equally well in making audible to those present various messages, songs and pieces of music conveyed to them by wireless telephony from a source at some distance from the lecture hall.

Dr. Edridge-Green, whose theories on colour-blindness were for many years regarded with suspicion, has now established his claim to be recognised as an authority on the subject, and his recent appointment as Special Examiner in the sight tests to the Board of Trade has stamped his claim with the hall-mark of official recognition. In 1910 he read a paper before the Society, in which he criticised the wool tests that had been for so long in use in examining railway and other workers. In the paper which he read here in November last, he described how persons can be classified according to the number of colours they can see as heptachromic (those who see seven colours), hexachromic, pentachromic, tetrachromic, trichromic, dichromic, and, finally, the totally colour-blind. He also gave an account of the spectrometer, an instrument devised by himself, whereby the precise nature and amount of a man's colour-blindness may be detected. As the result of his life work, a great deal has been done to eliminate the danger of placing in positions of responsibility on railways, ships, etc., persons who are colour blind to a perilous extent and who are yet able to pass the wool tests.

Mr. E. A. Brayley Hodgetts, who has had a very long and intimate connexion with Russia, traced the personal influence which has been exercised by Britons in that country. Among the more important people whose characters he sketched were Sir Roderick Murchison, well known for his work on the geology of the Ural Mountains; Henry Seebohm, who placed the ornithology of Siberia on a scientific basis; Patrick Gordon, the friend of Peter the Great, who rose to the rank of Major-General in the Russian Army; the two Greigs, Samuel and Alexis, who may be said to have created the traditions of the Russian Navy; Captain John Perry, Russia's first hydraulic engineer: and the two Wilsons, father and son, who carried out a great deal of architectural and engineering work. British influence at the Court—Catherine II. had her grandchildren educated by British nurses and governesses, a custom perpetuated after her day—and in literature was also described, and mention was made of the leading British firms and individuals who have contributed to the economic development of Russia in recent years.

The Embroiderers' Guild was founded with the object of promoting the art of embroidery in this country. Miss Louisa F. Pesel, President of the Guild, and herself one of the finest embroiderers of the day, read a paper. "Embroidery: National Taste in relation to Trade," in which, by the aid of a long series of lantern slides and a display of modern work, she showed the principal national features which have characterised the work of various countries from the early days of Egypt, Persia and Crete to the present time. In the discussion which followed the paper, the practical point was raised—How are embroiderers to compete with machinery? How are they to secure prices which will recompense them for the time and labour which they must expend on their work? There seems to be little doubt that some, at least, of the business houses would be glad to deal in such beautiful work as Miss Pesel exhibited if they could make sure of a market for it, but they do not appear to be any

too willing to take the risks involved in an attempt to educate public taste.

The various methods of burning oil for fuel in different parts of the world were described by Mr. Andrew F. Baillie. As compared with coal, oil possesses many obvious advantages: it is clean; it is easily pumped from ship to tank; no laborious stoking is needed to feed the furnaces; it is smokeless and makes no ashes which have to be removed. Mr. Baillie gave some interesting tables showing the comparative results of voyages made by ships and of journeys made by locomotives when fired with oil and with coal, the general effect of which was to make out a very good case for oil. The use of oil is also steadily increasing in factories, where, Mr. Baillie claims, it has led to greatly increased production, as well as enormous economy in floor space. The possible uses of oil as fuel are many and various: at least one large hotel in London now depends entirely on oil for its heating, hot water, and electricity supply, and is thus unaffected by coal strikes.

In 1919 Sir Frank Heath read a paper before the Society on "The Government and Scientific Research," in which he gave a general survey of the work of the Department of Scientific and Industrial Research, of which he is Secretary. He was followed this year by Mr. A. Abbott, Assistant-Secretary of the Department, who described the origin and development of the Research Associations established under the Government Scheme. At the time when Mr. Abbott's paper was read these Associations numbered twenty-three, and they are being constantly increased. The paper discussed the methods in which the Associations work, and the financial arrangements between them and the Department. Apart from the actual practical results obtained by the Associations, it seems clear that their formation has done a good deal to bring home to the public the necessity for research work in connexion with industry if Great Britain is to maintain her position in the industrial world.

Mr. Abbott's paper on the general work of the Research Associations was followed up by another, in which a more detailed account was given of a particular association—"The British Research Association for the Woollen and Worsted Industries," by Sir James P. Hinchliffe, its Chairman. After sketching the origin of the Association, Sir James described its present constitution, its connexion with the Department of Scientific and Industrial Research, and its financial arrangements. He then proceeded to discuss the various lines of research which are being undertaken at present or to be conducted in the near future. A freehold property of 3¾ acres, with a large house, near Headingley, Leeds, has been purchased, and the nucleus of a staff has been installed there. A number of problems connected with the woollen industry are being investigated, and already about a dozen publications, dealing with such subjects as the electrification of fibres, the action of acids, alkalies and soaps on wool, periodic faults in yarn, scouring, etc., have been issued. One of the most important matters engaging the attention of the Association is sheep breeding, and it is interesting to note that this year for the first time the Government are subsidising and supporting the breeding of sheep in the same manner as they have hitherto subsidised the breeding of horses, cattle and pigs.

The Trueman Wood Lectures were inaugurated in 1918 by Sir Dugald Clerk, who was followed in successive years by Sir Herbert Jackson and Sir Oliver Lodge. This year the lecture was delivered by Sir Daniel Hall, the subject being "The Present Position of Research in Agriculture." No man living has contributed more to agricultural research than Sir Daniel, whose work as the first Principal of the South Eastern Agricultural College at Wye, as the Director of the Rothamsted Experimental Station, as a Development Commissioner, and as Permanent Secretary, and finally as Scientific Adviser to the Ministry of Agriculture, is too well known to call for more than reference here. After outlining the reasons which led the Government to encourage the conduct of research by universities and kindred institutions rather than by a State Department, Sir Daniel described the work at present being carried out at Rothamsted, Cambridge, Oxford, Reading and elsewhere. He next dealt with the finance of the Government Scheme. The total set aside for research purposes this year is £105,000. About £10,000 is devoted to the Cambridge Institute dealing with Animal Nutrition. In view of the importance of the work carried on there, it is extremely desirable that the resources of the Institute should be largely increased,

and Sir Daniel suggested that, as the annual output of live stock and animal products in the United Kingdom is estimated at about £350,000,000, it should not be impossible for the producers to contribute another £10,000 for this purpose.

The Aldred Lecture was delivered by Dr. C. S. Myers, on "Industrial Fatigue." A great deal of work has recently been carried out, particularly in this country and in America, in studying the methods by which manual workers can work with the greatest efficiency. The elimination of needless muscular activity, the provision of suitable seating accommodation, ventilation, lighting and temperature—these are only some of the points that have been investigated. Dr. Myers summarised the present position of our knowledge on the subject; he described some of the instruments by which the researches are being conducted, such as the dynamometer and ergograph, and how these laboratory methods have proved of value in the determination of efficiency in ordinary life. The importance of the science is growing steadily. Tests for vocational selection are being generally adopted; the relation of output to improved distribution of hours of work and rest is being widely investigated; and the scientific study of workers' movements is being systematically undertaken. That the value of this work has come to be recognised is shown by the fact that we have in this country an Industrial Fatigue Research Board, which is carrying on inquiries on behalf of the Government for the industries as a whole, and a new National Institute of Industrial Psychology, which is making similar investigations for the benefit of individual industrial and commercial firms and their workers.

Mr. F. M. Lawson, in a paper entitled "The Future of Industrial Management," stated his belief that the only way to industrial peace lay in legislation which should require that any person, before taking up a position of authority in any industry, should first obtain a certificate showing that he was qualified to discharge the duties which would fall upon him. No one is permitted to hold the office of mate or captain until he possesses a mate's or a captain's certificate: why, then, he argued, should incompetent persons be permitted to hold appointments in industrial firms? The discussion that followed the paper showed that those present did not share Mr. Lawson's belief that so simple a prescription would provide a panacea for industrial unrest.

An interesting experiment on a wide scale is being attempted by the Peruvian Government to improve the breeding of sheep, llama and alpaca in Peru, with a view to supplying finer raw material for the textile trades. Colonel Robert J. Stordy, under whose superintendence the work is being conducted, read a paper on the subject. He described the great potentialities of Peru for maintaining immense flocks of sheep, llama and alpaca—potentialities which, at present, are almost neglected. The science of breeding is still unknown in Peru: the sheep are small and degenerate from close in-breeding, and the primitive methods of the natives, who shear with a knife or a piece of glass, do not tend to improve the quality or increase the quantity of the wool. By introducing scientific methods of breeding and animal management generally, Colonel Stordy hopes that an enormous development may be made in the quality of the various wool and hair-bearing animals of Peru, and that the commercial prospects in connection with such development will prove to be of considerable value and extent.

When the Forestry Commission came into being two years ago, Great Britain, alone among the nations of Europe, possessed no forest policy and no forest authority. Lord Lovat, the first Chairman of the Commission, described the action that had already been taken by this body, and outlined the general policy that will guide their future action. It is proposed to replant and afforest an area of 250,000 acres at the rate of 25,000 acres a year, and so far the Commissioners are well ahead of their schedule. Arrangements have also been made for the education of forest officers, landowners and land agents, and practical foresters, and a number of bulletins have been published providing valuable information on various subjects connected with forestry. Consultation Committees have been formed for various parts of the kingdom, while the outstanding feature of last year's work was the Imperial Forestry Conference, when for the first time forest representatives from every Dominion and practically every Crown Colony, met together and discussed questions of interest to the forest world. As a result of this conference steps have already been taken

to establish a permanent Imperial Forestry Bureau.

"Some of the Problems of Unemployment" was the title of a paper by Mr. E. C. de Segundo. Among the various remedies for the troubles of the time he urged the need of educating young persons in the observance of the moral law and in the rudiments of ecomomic science; he also pleaded for the proper encouragement of new industries and their protection for suitable periods, and for restricting the powers of Government to involve the country in heavy annual expenditure without adequate consideration. But, perhaps, his most striking remedy was the proposal to establish an industrial army, the members of which should receive wages whether at work or not, just as the soldier, sailor and policeman are paid, whether on active service or not. As was pointed out in the discussion, this proposal meant a revolution in industry similar to that involved in the Right to Work Bill, which was introduced into the House of Commons by the Labour Party. The paper gave rise to a long and interesting discussion.

Captain T. Manclark Hollis described the work of the Village Centres Council, who have established a colony for the re-education of the disabled at Enham, in Hampshire. Here, men seriously disabled in the war, are taught trades which they can follow in spite of their disabilities, such as basket-making, carpentry, small holding and farming, poultry rearing, market gardening, forestry and rural wood industries, etc. An important point in the scheme is that this training is conducted concurrently with their medical treatment: thus suitable occupation is provided for them during long, and often tedious periods of convalescence, with consequent beneficial effects upon their mental attitude. When the centre at Enham is fully developed it is hoped to provide a temporary side, dealing with 300 to 400 men at a time, and a permanent community consisting of 150 to 200 men with their families.

In 1909, Mr. James Buckland read a paper in which he pointed out the need for legislation to prevent the extermination of numerous species of birds whose plumage is used for millinery purposes. In spite of efforts on the part of many influential persons to secure the passage of the Plumage Bill, the situation at the beginning of the year was much as it was twelve years ago. It was, therefore, felt that the time had come when it was desirable to put forward a fresh statement of the case, and Mr. Willoughby Dewar, Hon. Secretary of the Plumage Bill group, undertook the task. There is no doubt that the wholesale destruction of the birds at their breeding season, when their plumage is at its greatest perfection, involves an immense amount of cruelty. The extent of this destruction can be gauged from Mr. Dewar's statement that in a single year some 35,000,000 wild birds' skins were imported into this country. Quite apart, too, from humanitarian considerations, there is a real danger that the extermination of birds which keep destructive insects in check, may lead to unknown perils to the human race: when the equilibrium of Nature is once upset no one can foretell what the results may be. The United States have already taken steps to protect their own birds and to prohibit the importation of skins and plumes from abroad. Similar steps have also been taken in India, Australia, Canada and New Zealand; and it is satisfactory to learn that, thanks largely to the efforts of the Plumage Bill Group, and its founder, Mr. H. J. Massingham, this country has at last decided to pass legislation which is demanded alike by humanity and by prudence.

Mr. C. Ainsworth Mitchell read a paper in which he discussed the part played by science in the investigation of crime. Although it cannot be denied that science has assisted the criminal in his work and provided him with rapid means of disappearing from the scene of his crime, Mr. Mitchell claims that each fresh practical application of scientific discovery has reduced the chances of an evil-doer escaping from justice. A hundred years ago everyone who committed a secret crime had an even chance of evading capture; now, owing to the power of rapid communication possessed by the authorities, his chances are very much less. He dealt at some length with the various means of identification, of detecting poisons, forgeries, etc., and finally suggested the establishment of a criminological society, such as exists in France, in which the work of experts in various scientific fields might be co-ordinated and placed at the disposal of the authorities.

Although pneumatic elevators have been in use for many years, it is only recently that systematic attempts have been made

to study the theory of the machines, and to work out the equations which govern their behaviour. A great deal of this work has been carried out by Dr. William Cramp, who gave a *resumé* of the results in his paper, "Pneumatic Elevators in Theory and Practice." The investigations were conducted in the laboratories of Sir Joseph Petavel, at Manchester, and in the course of them numerous experiments were made with a view to improving the efficiency of the various parts of the machine. Dr. Cramp described the way in which these experiments were done, and the formulæ which he has worked out will, no doubt, go far to set the manufacture of these elevators on a scientific basis. Hitherto the methods of the manufacturers have been almost entirely empirical.

The question of improving the industrial art of this country is one that is taxing the brains of a good many societies and individuals at the present time. There are three main factors in the problem—the manufacturer, the middleman and the public; and each is inclined to blame the other two for the existing lack of taste that appears to be so general. Professor William Rothenstein, in his paper, "Possibilities for the Improvement of Industrial Art in England," expressed his belief that we underrate the public taste at present, and that if manufacturers would supply more artistic goods the public would be glad to buy them. He also pleaded for a more generous treatment of the designer by the manufacturer. He desired to see in the Art Schools of the country places where students might receive a general artistic education conceived on liberal lines, and he deprecated the idea that they should be regarded merely as technical schools for training students ready to go at once into local industries as designers or craftsmen.

The optophone, which was described by Dr. Archibald Barr, is an instrument designed to enable blind persons to read ordinary print. Its action depends upon the well known property of selenium, the electric conductivity of which varies in accordance with the amount of light to which it is exposed. A selenium bridge connected with a battery and a telephone receiver, and exposed to rapidly alternating illumination and eclipse will cause corresponding pulsations of current through the telephone and produce audible sounds of corresponding pitch and equality. This property was taken advantage of by Dr. E. E. Fournier d'Albe in designing the optophone. A selenium bridge, exposed alternately to illumination from white paper and then to eclipse from black print, converts these impressions into sounds which can be read as letters. The mechanism of the instrument, originally designed by Dr. Fournier d'Albe and greatly improved by Dr. Barr, is extraordinarily delicate and ingenious, and yet its manipulation is so simple that it can easily be operated by a blind person. At the meeting at which Dr. Barr's paper was given, a blind lady read from ordinary type a passage which she had not previously known, at the rate of about 25 words a minute. This, of course, is not a speed that is of much practical value; but it must be remembered that the instrument is as yet in its infancy, and there seems good reason to hope that, as it is developed, and as blind persons are educated in its use, it will afford wonderful possibilities to the blind to read literature from which they are at present wholly debarred.

"Not a halfpenny should be spent, not a minute wasted, in further enquiry into the 'Smoke Nuisance,'" said Professor Henry E. Armstrong, in his paper, "Low Temperature Carbonisation and Smokeless Fuel." We know enough of the danger to health and the destruction of property due to smoke: the problem now is to find a satisfactory fuel. Professor Armstrong, who has studied the subject for many years, gave a brief historical sketch of the attempts which have been made to solve the problem, and then described the process of manufacturing coalite, a material which in his opinion gives better results than any other solid fuel. The early history of coalite was somewhat chequered, but during the last few years great improvements have been effected in the works at Barnsley, and the plant which was completed in 1920 is now working satisfactorily. In this process coal is carbonised at about 500°C.; the resulting coalite burns with a bright cheerful glow, while the coal-oil distilled from it possesses valuable characteristics as a fuel oil.

A machine for the use of men who have lost both arms at the shoulder was described by Sir James Cantlie. The invention of Mr. George Thomson, of Edinburgh, the apparatus consists of a small table beneath which are two rolls; on the ends of these are metal pegs by which the movements

are made by the feet. The foot rods are attached to uprights which are attached to and come up above the side of the table further off the worker. To the top of the upright pieces the "arms" of the apparatus are attached and project towards the worker, coming about half way across the table. The upright pieces are firmly attached to the table and furnished with hinges and joints moveable in almost any direction. The upright parts of the instrument move about like a double-winged gate, and the movements are thus conveyed from the movable foot rods below to the movable arms above. The arms are fitted with "hands" which can pick up tools, such as knives, forks, spoons, etc. A demonstration was given by an armless man who, with the help of this machine, went through a four-course dinner, drank a cup of tea, picked up a cigarette, struck a match, lighted the cigarette, and carried out many other acts of a similar nature.

In a second paper read on the same evening Sir James described an X-Ray motor-ambulance waggon, by means of which, instead of a patient being taken to a hospital to be X-rayed, the X-Ray apparatus is taken to the patient's room. In this way a great deal of suffering is avoided. It is hoped to establish a service of such waggons covering the whole of the kingdom, and thus to bring X-Ray apparatus within easy reach of the general practitioner throughout the country.

In his paper, "Anglo-American Relations: A Personal Impression," Sir Geoffrey Butler gave a summary of the views which he formed while acting as Director of the British Bureau of Information in the United States from 1917-19. Although, of course, American legal institutions and practices are dominated by British thought, it is useless to disguise the fact that Great Britain and America are separate countries; and instead of vainly repeating that blood is thicker than water, Sir Geoffrey urged that we should study America. In recent years America has developed schools of her own, especially in architecture, literature (notably the short story), physical chemistry and bio-chemistry, law, and medicine, and it is at least as educative for the British student to visit America as for the American student to visit Britain. The movement in both directions is to be encouraged to as great an extent as possible: in mutual knowledge lies the surest road to mutual understanding.

In his paper, "Some Effects of the War on Industrial Unrest," Dr. C. M. Wilson expressed his belief that much of the present discontent emanated, not so much from the ex-soldier as from the man who stayed at home. It is the result of a morbid mental state, due to the loss of self-respect in the case of the man who stayed at home of his own free will, and a sense of injustice in the case of the man who was prevented from going. This was the most fertile soil in which grievances flourished. While many of the present-day problems were older than the war, the mood in which the workers were advancing their grievances was almost entirely a by-product of the war. To unravel the knot in which capital and labour had become tied, it was important to approach this mood with understanding and sympathy. If it was accepted that the real motive force to-day was not political but economic, and that the mass of people simply wished to better their conditions, it was wise to meet that wish so far as was compatible with industrial prosperity.

Sir Kenneth Goadby, in his paper, "Immunity and Industrial Disease," discussed the incidence of industrial disease, and explained certain remedial measures which deserve the attention of public authorities and trade unions. He also dealt with the question of susceptibility. The white corpuscles of the blood are the chief agents in destroying dangerous microbes or poisonous substances that have gained access to the body. If they are not present in an individual in the usual proportions, his powers of resistance are subnormal. Sir Kenneth suggested that a blood test should be made in the case of every man who proposes to enter a dangerous trade, and in this way he hoped to substitute prevention of disease for its cure.

III.—Indian and Colonial Sections.

Including the Sir George Birdwood Memorial Lecture, "The Common Service of the British and Indian Peoples to the World," by Lieutenant-Colonel Sir Edward W. M. Grigg, the Indian Section, held five and the Colonial Section three meetings. There was also one joint meeting of the two sections.

Taking them chronologically, the Indian papers were as follows:—"British Trade with India," by Mr. Thomas M. Ainscough, H.M. Senior Trade Commissioner in India

and Ceylon; "Indian Timbers," by Professor R. S. Troup, School of Forestry, University of Oxford; "Paper Pulp Supplies from India," by Mr. William Raitt, Cellulose Expert to the Government of India; and "The Development of Bombay," by Sir George Curtis, late Member of the Bombay Executive Council.

The Colonial papers were:—"Industrial Developments in Australia during and after the War," by the Agent-General for Tasmania, Mr. Alfred Henry Ashbolt; "Modern Agriculture," with special reference to progress in Canada since Confederation in 1866," by the Agent-General for Ontario, Dr. George C. Creelman; and "The Alluvial Diamondiferous Deposits of South and South-West Africa," by Mr. F. C. Cornell, author of "The Glamour of Prospecting."

The paper read at the joint meeting was "Industrial (including power) Alcohol," by Sir Charles H. Bedford.

In what the Chairman of the meeting, Lord Lytton, termed a "very eloquent, charming and in every way delightful lecture," Sir Edward Grigg quoted Spencer Walpole's verdict that "Centuries hence some philosophic historian will relate the history of the British in India as a romantic episode which has had no appreciable effect upon the progress of the human family." The lecturer adduced reasons why that verdict should be tempered or, as he himself hoped, reversed. In analysing the distinctive contributions of British and Indian genius to Indian progress during the past century and indicating how striking in its results that achievement was, he submitted that the Indian nationalism of our time is "not only the product but the justification of British rule." To him it was a complete misreading of the past century to suppose that the reaction of India to British rule has been "merely the passive reaction of material to a moulding hand." Indian allegiance to the Raj has been given, broadly speaking, as a reasoned and contented choice. Special interest attached to Sir Edward Grigg's lecture as the late Viceroy, Lord Chelmsford, availed himself of the occasion to make his first speech in public since his arrival from India only two days previously.

The primary object of Mr. Ainscough's paper was to consider India as our greatest market and to suggest means by which we may retain our commercial pre-eminence there, notwithstanding the industrial renaissance of which we hear so much and the new factor that has arisen out of the Great War, viz., the formidable American and Japanese competition. One of the remedies he proposed is a new distributing system, the one now in existence having been designed when our position was still unchallenged. In what ought to be a fruitful discussion the desirability of greater trade co-operation between Britons and Indians was urged by the Comptroller-General of the Overseas Trade Department (Sir William Henry Clark) and others. One view expressed was that our manufacturers would be well advised if instead of opening branches in India, they started new businesses there with capital raised locally.

India possesses nearly, if not quite, 2,500 species of indigenous trees, but the proportion which rank at present as important timber trees is not large, and of these only a portion can be placed in the category of trees yielding timbers likely to gain a footing in European markets. It was with the latter that Professor Troup dealt. He pointed out that while India cannot compete with Scandinavia, Canada, and some other countries in so far as timbers of the cheaper grade are concerned, it is doubtful if any part of the world can show as varied a selection suitable for high-class decorative or constructional work, furniture, etc. All who visited the Indian Section of the recent Empire Timber Exhibition will share Professor Troup's hope that the appointment of a well-known London firm as Government timber agents will lead to a wider use in Great Britain of the beautiful woods that India produces.

Mr. Raitt gave some very interesting information about the important subject of his paper. The net result of the investigations conducted by the Forest Research Institute at Dehra Dun, is the discovery so far of only two groups of species for paper-making purposes that appear to be economically sound—Bamboo and certain Savannah grasses. But he thinks it is a modest estimate to say that from bamboo, "taking only that which is available under *possible* manufacturing conditions" Burma, Bengal, and South-West India could produce from bamboo ten million, and Assam from Savannah grasses three million tons of pulp annually. "India could therefore produce pulp for the whole world."

In the development of the extensive measures now being undertaken to remodel what its inhabitants claim to be the "second city in the Empire" Sir George Curtis has had a large share, and his excellent paper is the first complete account that people at home have had of the far-sighted policy of the Government of which until a few weeks ago he was a member. In some of the schemes he described, notably the Back Bay reclamation, which alone is expected to cost five million sterling—the whole work, excluding a new dock, will involve an outlay of at least £30,000,000—the Bombay Government is directly concerned. The carrying out of other parts of the programme is in the hands of local bodies, viz., the City Improvement Trust—the earlier housing work of the Trust, under the inspiration of Lord Sandhurst, was dealt with in a paper read before the Indian Section in 1910 by Mr. G. Owen Dunn—the Municipality; and the Port Trust.

Previous to the War 60 per cent. of the manufactured goods imported into Australia were obtained from the Mother Country. During the War this source of supply was cut off and the Commonwealth was obliged to turn to America and Japan for the satisfaction of her immediate needs. But at the same time, with characteristic energy, she set about reorganising her existing industries and creating fresh ones. Statistics show that in 1917, her production was 50 per cent. higher than in 1909, and there has since been still further growth. Mr. Ashbolt urged British manufacturers to recognise the fact that the Australian people are "wedded for all time to the ideals of Protection," and, instead of letting the matter go by the board, to join with Australians in establishing manufactories on the spot. Already three of our large manufacturers of confectionery have combined to erect huge works at Hobart, so as to meet the changed and changing conditions.

As a former able head of the well-known Agricultural College at Guelph, Dr. Creelman was eminently fitted for the task of dealing with Canada's progress in agriculture since the Dominion adopted Confederation fifty-five years ago. He mentioned with justifiable pride, that in 1917, when the wheat resources of the Allies were beginning to run out, Canada succeeded in producing 393,000,000 bushels of that grain which, as Sir Daniel Hall remarked in opening the discussion on the paper, was a vital factor in the prosecution of the War.

Mr. Cornell in his attractive paper describing the river diggings of South and South-West Africa, selected those of the Vaal as typical though larger than the rest. The diamonds in these alluvial deposits, he showed, are sparsely and unevenly distributed and hitherto their actual source has been rather mysterious. His opinion that nobody should rush out to South Africa and start digging was endorsed by another distinguished South African visitor Professor Ernest H. L. Schwarz.

Widespread interest has been aroused, especially in transport circles, by Sir Charles Bedford's valuable and timely paper on the subject of establishing a great new industrial alcohol industry within the British Empire. For the past two years Sir Charles Bedford has been entirely engaged in the investigation of new waste or semi-waste materials for the object in view, and he has recently spent six months in Burma on work connected with the large-scale production of industrial alcohol from rice-straw. "It may," he observed, "now be said with safety that the result is satisfactory (and it is also the considered opinion of the various leading commercial and technical experts in England and France, with whom I have been in touch) and that there is no doubt that alcohol can be made from rice-straw on commercial lines under the conditions employed."

IV.—Cantor Lectures.

The first course of Cantor Lectures was delivered by Mr. A. Chaston Chapman on "Micro-Organisms and some of their Industrial Uses." An account was given of recent views on the mechanism of alcoholic fermentation, and the nature of the intermediate products. The use of bacteria in the amylo-process was described, and this was followed by an account of the manufacture of lactic acid and butyric acid by fermentation processes, etc. In the last lecture of the course, after referring to the bacterial production of acetone and butyl alcohol, the utilisation of waste distillery liquors and kindred points, the lecturer concluded with a plea for the extended study of industrial micro-biology in the country, and for the establishment of a national institute devoted to the subject.

In 1918 Professor James C. Philip gave a course of lectures on Physical Chemistry, in which he dealt with the general principles of the subject. The second course of Cantor Lectures this session was delivered by Mr. Eric K. Rideal, and was entitled "Applications of Catalysis to Industrial Chemistry." After giving a general account of the theories of catalysis, and the technical difficulties involved, the lecturer discussed three main subjects: (1) processes of oxidation; (2) processes of hydrogenation; and (3) hydrolytic processes. The first heading included such subjects as the manufacture of sulphuric acid, nitric acid, incandescent mantles, linoleum, etc.; the second, the preparation of hydrogen, methane, ammonia, and synthetic rubber; while the third dealt with saponification, glucose, alcohol, acetic acid, acetone and ether.

"X-Rays and their Industrial Applications" was the subject of the third course, delivered by Major G. W. C. Kaye. The first lecture described the nature of X-Rays, their generation, their various types and their efficiency; the second dealt with high potential generators, the measurement of X-Ray spectroscopy; and the third with the application of X-Rays to various industrial and medical purposes. The use of X-Rays in medicine has, of course, been familiar for some years, though probably few people outside the medical profession realise the extent to which it has lately been developed in this connexion. Equally few are aware of the use which is being made of them in industry. During the war it was found that they were invaluable in detecting flaws in wood used in the construction of aeroplanes, in metals, and such substances as rubber, etc.; and there seems to be little doubt that in the future their use for these and similar purposes will be very greatly extended.

The last course, delivered by Dr. Samuel Judd Lewis, was entitled "Recent Applications of the Spectroscope and the Spectrophometer to Science and Industry." The lecturer explained how spectra could be used in the analysis of complex substances, both by qualitative and quantitative methods. He also explained and demonstrated the value of spectrophotometers in examining the ultra-violet region of the spectrum. Ultra-violet absorption spectra of various substances, such as blood sera, cellulose films, etc., were thrown on the screen and discussed, and the course concluded by demonstrating how spectroscopic instruments could be applied to the study of fluorescence in paper, textiles and other materials.

V.—Howard Lectures.

A course of three lectures on "Aero Engines" was delivered under the Howard Trust by Mr. Alan E. L. Chorlton. The first was historical, and dealt with the development of aero engines from the earliest attempts to produce motive power for flight up to 1914. The second described the extraordinary development which took place during the war, while the third was devoted to an account of engines in use after the war, and the conditions governing and limiting further progress.

VI.—Juvenile Lecture.

Sir Frederick Bridge, in delivering a Juvenile Lecture on "The Cries of London which children heard in Shakespeare's time," contrived to give a very good idea of the sights and sounds to be seen and heard in London streets in the sixteenth and seventeenth centuries. Music was then a more general accomplishment than it is to-day: every educated person was expected to be able to read at sight and to sing his part in a ballad. The cries of street hawkers and vendors were correspondingly musical, and as most of these have been preserved in the works of Welkes, Orlando Gibbons, John Cobb, Richard Deering and others, Sir Frederick Bridge, with the aid of four singers, was able to reproduce them as they were actually and habitually sung. The lecture threw an interesting light on the everyday life of Shakespearean London.

VII.—Albert Medal.

The Albert Medal of the Society for 1921 has been awarded by the Council, with the approval of the President, H.R.H. The Duke of Connaught and Strathearn, K.G., to Dr. John Ambrose Fleming, F.R.S., in recognition of his many valuable contributions to electrical science and its applications, and specially of his original invention of the Thermionic Valve, now so largely employed in wireless telegraphy and for other purposes.

For upwards of forty years Dr. Fleming has been closely associated with the scientific development of electrical industry, and manifold have been the ways in which he has assisted its advancement. As long ago

as 1879 he was the scientific adviser of the Edison Telephone Co., when it was formed to begin Telephone Exchange working in London; while in 1882 and for many years after he held a similar scientific position with the Edison and the Edison and Swan Companies then engaged in the introduction of electric lighting by incandescent lamps. Again, later, in 1899, when wireless telegraphy began to be practically applied, he gave much scientific assistance to the Marconi Company in the development of its system and its application to wireless working over long distances.

For 36 years he has occupied the chair of electrical engineering at University College, London, and in addition to his ordinary teaching, during that time has given something like 100 separate lectures before the Royal Institution, the British Association, and other scientific bodies, including 30 discourses before the Royal Society of Arts. Many of these lectures were beautifully illustrated by experimental demonstrations. As a contributor to scientific literature he has been unusually prolific, his contributions to the transactions of various learned societies amounting in all to some 90 scientific memoirs in the proceedings of the Royal Society, the Physical Society, and the Institution of Electrical Engineers, besides which he is the author of 16 text books on electrical subjects, many of which have had a world-wide circulation. Amongst the best known of these are his books, "The Principles of Electric Wave Telegraphy and Telephony"; The Alternate Current Transformer"; and "The Thermionic Valve and its Development in Wireless Telegraphy."

His original invention in 1904 of the Thermionic Valve, in which the emission of electrons by a negatively charged incandescent filament enclosed in a vacuum is employed to rectify alternating and oscillatory electric currents, was the first practical step in the evolution of the modern thermionic amplifier, with which very minute electrical effects can be enormously magnified. His work has also led to the production of the thermionic oscillator now much used for the generation of wireless waves. These instruments have not only revolutionised wireless telegraphy and telephony, but have also enabled ordinary wire telephony to be extended over distances much greater than those that were previously practicable. In addition they have other important applications that are only just beginning to fructify.

Dr. Fleming's scientific work has already been recognised by the Royal Society, who, in 1910, awarded to him their Hughes Gold Medal.

VIII.—Medals for Papers.

It has been decided to award nine medals for the papers read before the Society during the present session—five for papers read at the Ordinary Meetings, two for those read in the Indian Section, one for those read in the Colonial Section, and one for that read at a Joint Meeting of the Indian and Colonial Sections.

The following awards have been made:—

Papers read at the Ordinary Meetings:—

Major-General The Right Hon. Lord Lovat, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., "Forestry."

Colonel Robert J. Stordy, C.B.E., D.S.O., "The Breeding of Sheep, Llamas, and Alpacas in Peru, with a view to supplying improved Raw Material to the Textile Trades."

Andrew Francis Baillie, Chief Engineer, Technical Department, Anglo-Mexican Petroleum Company, "Oil Burning Methods in various Parts of the World."

William Cramp, D.Sc., M.I.E.E., "Pneumatic Elevators in Theory and Practice."

Sir Kenneth Weldon Goadby, K.B.E., M.R.C.S., D.P.H., "Immunity and Industrial Disease."

Papers read in the Indian Section:—

William Raitt, F.C.S., Cellulose Expert to the Government of India, "Paper-pulp Supplies from India."

The Hon. Sir George Seymour Curtis, K.C.S.I., "The Development of Bombay."

Paper read in the Colonial Section:—

A. H. Ashbolt, Agent-General for Tasmania, "Industrial Development in Australia during and after the War."

Paper read at a Joint Meeting of the Indian and Colonial Sections:—

Sir Charles H. Bedford, LL.D., D.Sc., late Chemical Examiner to the Government of India, "Industrial (including Power) Alcohol."

For many years it has been the practice that no medals should be awarded to readers of papers who had previously received medals from the Society. Acting on this rule, the Council were precluded

from considering the following papers:—

Edward C. de Segundo, Assoc.M.Inst. C.E., M.I.Mech.E., M.I.E.E. "Some Problems of Unemployment."

Sir James Cantlie, K.B.E., LL.D., F.R.C.S., "(1) Thomson's Apparatus for Armless Men; (2) X-Ray Motor Ambulance Service for the United Kingdom."

The Council, however, desire to express their appreciation of these papers.

IX.—Owen Jones Prizes.

With the kind assistance of the Director of the Victoria and Albert Museum, the Council again in 1920, arranged for a competition of students of Schools of Art in accordance with the terms of the Owen Jones Trust.

The subjects of the competition were:—(1) Domestic Pottery and Table Glass; (2) Metalwork: including work in Precious Metals, Ironwork, Jewellery, Enamelling, etc.; (3) Textiles: including Lace, Embroideries, Openwork, Dress Brocades, Dress Designs and Costume Accessories, Printed Fabrics for Dress.

Ninety-four designs or works were submitted by sixty-three competitors from seventeen centres. These figures compare favourably with those of last year, when fifty designs were sent in from nine centres by thirty-one students, though they are still a good deal smaller than the totals for 1917, when one hundred and twenty designs were submitted by seventy-three students from twenty-two schools.

In accordance with the recommendations of the Judges, the special prize of £20, which was offered in order to encourage the competition, was awarded to Miss Evelyn M. Scott, of the City School of Art, Liverpool, for an embroidered panel for a fire screen; and five out of the six ordinary prizes were also awarded.

The work was exhibited to the public at the Victoria and Albert Museum from July 21st to August 31st.

Full information of the conditions of the competition in 1921 were published in the *Journal* of April 8th last (p. 317).

X.—Examinations.

The Examinations now form a very important part of the work of the Society. Their growth has been steady since the beginning of the century. The number of entries was naturally affected by the war, but the figures of the last two years show that the falling off was merely temporary, and the totals are now very much larger than ever. There can be no doubt as to the popularity of the Examinations: they supply exactly what is required by commercial students, who find the Society's certificates of much service in assisting them to obtain employment or to improve the positions which they already hold. The syllabuses have been modified from time to time to meet expressed wants. The object of the Council has always been to supply what seemed to be required, and not to impose any hard and fast system upon students. There has been a free and elastic programme, without restrictions as to age or sex, and candidates have been left at absolute liberty to select the subjects in which they desired to obtain certificates.

The appreciation by local Education Authorities and by students themselves of the Examinations, is shown by the fact that the enormous increase in the number of entries for the examinations which took place in 1920 has been more than maintained this year. At the March examinations there were 16,658 entries, and at the May examinations, 38,524 entries, making a total of 55,181. In 1921 the total increase over last year's figures was 1,172. In order to shew the growth of the examinations in recent years, the figures are given for the last three years, and also for 1914, which was then the record year:—

Year.	*Number of Entries.*
1914	37,974
1919	34,173
1920	54,010
1921	55,182

It was mentioned in the Annual Report for 1920 that the Examinations Committee were revising the various syllabuses. In accordance with their recommendations certain changes were introduced of which the most important are—(1) the addition of an oral examination for all candidates entering for French, German, Spanish and Italian in Stage III. (Advanced); and (2) the addition of the following subjects in Stage III.:—"Shipping Law and Practice," and "Railway Law and Practice."

The liberality of the Worshipful Company of Clothworkers has enabled the Council, as in past years, to offer the usual silver and bronze medals. These medals are very highly valued by the successful candidates, and there can be no doubt that they contribute not a little to maintain the high standard of the examinations.

The results of the First Division of the Examinations, held in March, have already been communicated to the candidates; and those of the May Division will be announced as soon as possible.

The usual detailed report on the year's Examinations will be published in the *Journal* at a later date.

XI.—Viva Voce Examinations in Modern Languages.

In consequence of oral tests having been made compulsory as part of the Stage III. examinations in French, German, Spanish and Italian, there has been a considerable increase in the number of candidates this year, the total being 843 as compared with 431 in 1920. The oral examinations for candidates in the provinces have already been held, and those for candidates from L.C.C. Commercial Institutes will take place shortly.

Up to the present date 38 examinations in French, German and Spanish have been held at Provincial Centres and 20 in the London District. At those examinations 648 candidates presented themselves, of whom 523 passed (177 with distinction) and 125 failed.

XII.—Industrial Art.

It was stated in the last Annual Report that the Industrial Art Committee had been in communication with Sir Frank Baines, of H.M. Office of Works, which required a considerable quantity of furniture for various purposes. He was convinced that the views of the Committee were sound, viz., the furniture of good but very simple modern design, entirely free from meretricious ornament and of fine workmanship, would prove to be better and more economical than anything obtainable at reasonable prices to-day; and he invited the Committee to exemplify their views by submitting to H.M. Office of Works specimens of such designs as they would recommend for adoption.

In accordance with this invitation, five designs for dining-room furniture (a chair, an elbow-chair, a dining-table, a side-board and a side-table) were prepared by the Design and Industries Association in accordance with specifications supplied by H.M. Office of Works. It is satisfactory to record that these designs not only served the purpose for which they were intended, namely, to illustrate the arguments put forward by the Committee, but were themselves found suitable for adoption, and H.M. Office of Works have invited tenders from manufacturers for supplying furniture made to these designs. The manufacturers whose tenders are accepted, will be permitted to dispose of furniture, made to these same designs, through retailers to the public.

The Committee feel that a practical result has been achieved in securing the interest of a Government Department, with great purchasing power, in this question. They hope that by encouraging the demand for furniture of sound workmanship and simple design, manufacturers generally may be induced to improve the quality of their goods. This is a matter, the importance of which, from the national point of view, can hardly be over-estimated.

XIII.—Dr. Mann Trust.

Under the terms of the will of the late Mrs. Charlotte Elizabeth Mann, the Society has received a legacy of £1,000, to be devoted in the first instance to the institution of a course of lectures to be known as the "Dr. Mann Juvenile Lectures."* Dr. Robert James Mann was secretary of the African (now the Colonial) Section of the Society from 1874 to 1886. In the latter year was elected a member of the Council, but unfortunately he died a few months after his election.

Mrs. Mann died in June, 1920, at the great age of 98. She survived her husband by thirty-four years, but despite the lapse of this long time, she carried out the intention formed at the time of Dr. Mann's death to commemorate his association with the Society and the interest which he took in its work. The Council have now very great pleasure in reporting that his name is to be perpetuated under the Dr. Mann Trust.

XIV.—New Council.

The Vice-Presidents retiring under the ordinary regulations are Mr. P. M. Evans, Colonel Sir Thomas H. Holdich, Major-General Sir Desmond O'Callaghan, and the Hon. Sir Charles Algernon Parsons. In their places the Council recommend Sir Herbert Jackson, Viscount Northcliffe, Mr. James Swinburne, and Sir Philip Watts.

The five Ordinary Members of the Council retiring are Sir Herbert Jackson(who is

* Full particulars of the terms of the Trust and some account of Dr. Mann were published in the *Journal* of April 29th, 1921, pages 370-1.

recommended as a Vice-President), Major Sir Edward Humphrey Manisty Leggett, Sir Richard Vassar Vassar-Smith, Dr. John Augustus Voelcker, and Sir Frank Warner. In their places the Council recommend Sir William H. Clark, Professor John Bretland Farmer, Mr. George Sutton, and Sir Alfred F. Yarrow (none of whom have previously served on the Council), and Mr. Ernest H. Pooley.

XV.—Obituary.

The number of distinguished Fellows of the Society who have died during the last twelve months is fortunately smaller than usual.

Sir William de Wiveleslie Abney was elected a Member of the Council in 1894, and served on it almost continuously until 1915, being Chairman from 1903-05. He delivered four courses of Cantor Lectures, one Special Lecture and read six papers.

Lord Moulton served on the Council from 1890 to 1893, and again from 1914 to 1918. He was a member of the Royal Commission for the Chicago Exhibition of 1893, and went to Chicago as a representative of the Society.

Lord Belhaven and Stanton was a Member of the Council from 1885 to 1901.

Among other notable Fellows who have died during the year may be mentioned Mr. Maurice George Carr Glyn, Mr. Isham Randolph (the well-known American engineer) Sir Arthur Charles Trevor, Sir Lindsay Wood, Mr. Gerald Ritchie, Mr. J. D. Anderson, Mr. Neville Priestley, Sir Rowand Anderson, Sir Herbert Rowell, Sir Robert Nathan, Mr. William Lawrence Smith and Sir Merton Russell Cotes.

XVI.—Finance.

At the Annual General Meeting, held on June 30th, 1920, it was unanimously resolved to increase the annual subscription of Fellows of the Society from two to three guineas, and the life composition fee from twenty to thirty guineas. The changes were recommended by the Council with great reluctance, but, for reasons stated in the last annual report, it was felt that they had become absolutely necessary. As a result, the number of resignations received during the year was, not unnaturally, larger than usual, while the number of new elections, instead of steadily increasing, as it has during the last three years, has decreased

The increase of subscription came into effect at Michaelmas, 1920, so that during the year ending December 31st, 1920, the change affected two of the four quarters. It is not possible to make an accurate estimate of the result until the new conditions have been in operation for at least twelve months. The income and expenditure account, published in the *Journal* of June 24th, shows that the amount received from annual subscriptions and life compositions amounted to £8,271 3s., as compared with £6,261 14s. in 1919—an increase of £2,009 9s. It seems clear, therefore, that the increase of subscription has tended to improve the financial position of the Society.

In the last Annual Report attention was drawn to the great and constantly increasing cost of the *Journal*. This was mainly due to frequent advances in printers' wages, while the doubling of the postage rate in September last meant an additional expenditure of nearly £400 *per annum*. In these circumstances the Council felt that they could no longer print the *Journal* in London, and they transferred the work to Hastings, with the result that they expect to save a considerable amount on the printing

With the aid of this economy and the extra income derived from increased subscriptions, the financial position of the Society at the present moment seems to be satisfactory. The question of the Society's house is, however, causing the Council grave concern. It was mentioned in last year's report that their tenancy of the house, which they have occupied since 1775, will expire in March, 1922. The landlord has offered the Council the option of purchasing this freehold. The cost of buying and of renovating the house is estimated at £50,000. A few members of the Council and their friends have promised about £8,000 towards this object, and it was proposed to issue a general appeal to the Fellows. The conditions of the country have, however, been such that it was felt inadvisable to adopt such a course at present. It is possible that the landlord will agree to extend the Society's tenancy for another year or two, but if this is done, the rent will probably be greatly increased. The Council feel the extreme importance of doing everything in their power to retain the Society in possession of the historic house which

was built for them by the Brothers Adam, and in which it has carried on its work for nearly a century and a half, but they desire to place on record here their conviction that this will only be possible if they receive the generous co-operation of the general body of the Fellows.

The Chairman (Mr. Alan A. Campbell Swinton, F.R.S.) moved the adoption of the Report. The Report formed a very complete record of the activities of the Society during the past year, and he thought there was no doubt that they had had a most excellent series of papers and lectures this Session.

SIR HENRY TRUEMAN WOOD said he had much pleasure in seconding the adoption of the Report. It was a great satisfaction to himself personally, and he felt sure to all those interested in the welfare of the Society, to know that they had passed through with a very fair amount of success the troubles which everybody was undergoing, and he thought there was every prospect of a long career of usefulness for the Society. The change in the subscription was of course a risky undertaking as nobody liked to have his dues increased. It was therefore reassuring to learn from the Report that, as far as could be judged, the result had been eminently satisfactory, and the extra revenue formed a welcome addition to the resources of the Society. Naturally a certain number of Fellows had resigned in consequence, but, speaking as one having had long experience in such matters, he thought the number was very much less than might have been expected. There was one matter he would like to take the opportunity of referring to, and that was the question of the Society's premises, which was mentioned in the last paragraph of the Report. Some of the Fellows, he thought, might not be aware that the landlord, who is willing to sell the freehold of the Society's house, is unable to continue the lease. It therefore had become a question whether they could raise sufficient funds to purchase the freehold, or whether they would be obliged to go elsewhere for a home. They had received promises of very liberal donations from several members of the Council and their friends, amounting to about £8,000, which he thought showed admirable feeling on their part; but he hoped the general body of Fellows would also come to the help of the Society and enable them to purchase the freehold. The price asked by the landlord was perhaps not unduly high considering the value of the site, but unless the Fellows were prepared to raise a sum of £50,000, he thought it was quite likely they would have to look out for fresh premises. He believed they would not have much difficulty in obtaining accommodation elsewhere; still he considered it would be a disaster to the Society and an injury to the entire nation if the Society was obliged to quit the premises in which for over a century and a half it had done so much valuable work.

MR. CHARLES T. COURTNEY LEWIS enquired whether the charge of £4,541 7s. 5d. given in the Balance Sheet for 1920, as the cost of the Journal, included postage to Fellows, and criticised the size and general appearance of the Society's *Journal.*

THE CHAIRMAN said the cost of postage of the weekly *Journal* to the Fellows, namely £800, was included in the above amount. The *Journal* was a heavy charge upon the Society, but it was undoubtedly necessary, because in the case of Fellows who were unable to attend the meetings, it was all that they received in return for their subscription. He thought, and many others did so too, that the *Journal* was a publication of which the Society might very well feel proud.

MR. C. T. COURTNEY LEWIS was of opinion that a Society with so eminent prestige and doing such excellent work, ought to produce a better *Journal* at a less cost than £4,500 per annum, and he ventured to submit that the Council should not be content with a *Journal* of the present character.

THE CHAIRMAN pointed out that the main object of the *Journal* was to give publicity to the Society's Proceedings, and there was no question that the papers and lectures which appeared in it were of an exceptionally high quality. If other matter were added and the number of pages increased, the cost of production would be still greater. The Council had gone fully into the question of the cost of the *Journal*, and were anxious to cut down the expense of production as much as possible. Since November, 1920, the *Journal* had been printed out of London, and this change had effected a very considerable saving.

MR. CARMICHAEL THOMAS said it ought to be remembered that the Society's *Journal* was a weekly publication, not a monthly or quarterly *Journal* as was the case with

many Societies. In order to effect a saving it had been necessary to cut down the number of pages and confine it almost entirely to the proceedings of the Society.

MR. C. T. COURTNEY LEWIS asked if it had been considered advisable to have the *Journal* issued weekly, and whether there would be any saving if it was published monthly.

THE CHAIRMAN repled that the matter had been carefully considered, and the Council had come to the conclusion that there would be little or no saving.

SIR HERBERT JACKSON, K.B.E., F.R.S., expressed some surprise at the criticism of the *Journal*. He had always found it most interesting. He looked upon the back numbers as a mine of information, and had used them constantly for obtaining information on a large number of subjects. He knew of no similar publication covering so wide a field, and anyone possessing a set of volumes of the *Journal* had practically got a record of all developments in Arts, Manufactures, and Science. Many of his friends had told him that they were unable to attend the meetings and lectures, but joined the Society solely because they were anxious to have its *Journal*.

The adoption of the Report was then agreed to.

THE CHAIRMAN then moved the following Resolution :—

> That By-law No. 47, relating to the date of the opening of the session, be altered and amended by the substitution of the word "first" for the word "third."

The By-law, as amended, will read as follows :—

> By-law 47.—"The Session shall commence on the first Wednesday in November, and shall end on the last Wednesday in June."

The only reason for making the change, he said, was the Council thought that the Session might with advantage begin a little earlier in November than the present By-law allows.

The Resolution was put to the meeting and carried without any dissentients.

THE CHAIRMAN proposed a cordial vote of thanks to Mr. G. K. Menzies (the Secretary), Mr. S. Digby (the Secretary of the Indian and Colonial Sections), Mr. George Davenport (the Chief Clerk), Mr. J. H. Buchanan (the Accountant), and to the other officers of the Society for their services, and for the zealous way in which they had all carried out their duties during the past Session.

THE SECRETARY (Mr. G. K. Menzies) returned thanks for this expression of confidence in himself and in the other officers of the Society.

The ballot having remained open for half-an-hour and the scrutineers having reported, the CHAIRMAN declared that the following had been elected to fill the several offices. [The names in *italics* are those of Fellows who have not, during the past year, filled the office to which they have been elected.]

PRESIDENT :

H.R.H. The Duke of Connaught and Strathearn, K.G.

VICE-PRESIDENTS :

Lord Askwith, K.C.B., D.C.L.
Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.
Sir Steuart Colvin Bayley, G.C.S.I., C.I.E.
Lord Bearsted of Maidstone.
Sir George T. Beilby, LL.D., F.R.S.
Lord Blyth.
Sir Thomas Jewell Bennett, C.I.E., M.P.
Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.
Sir William Henry Davison, K.B.E., D.L., M.P.
Edward Dent, M.A.
Sir Robert Abbott Hadfield, Bt., D.Sc., D.Met., F.R.S.
Field-Marshall Earl Haig, K.T., G.C.B., O.M., G.C.V.O., K.C.I.E.
Sir Herbert Jackson, K.B.E., F.R.S.
Lord Leverhulme.
Viscount Northcliffe.
Major Sir Francis Grant Ogilvie, C.B., LL.D.
Hon. Richard Clere Parsons, M.A.
Lord Sanderson, G.C.B., K.C.M.G.
James Swinburne, F.R.S.
Carmichael Thomas.
Sir Philip Watts, K.C.B., LL.D., F.R.S.
Sir Aston Webb, K.C.V.O., C.B., P.R.A.
Sir Henry Trueman Wood, M.A.

ORDINARY MEMBERS OF COUNCIL :

Sir William H. Clark, K.C.S.I., C.M.G.
Charles Frederick Cross, F.R.S.
Professor John Bretland Farmer, M.A., D.Sc., F.R.S.
John Somerville Highfield, M.Inst.C.E., M.I.E.E.
Major Percy A. MacMahon, R.A., LL.D., Sc.D., F.R.S.
Sir Philip Magnus, Bt., M.P.
Ernest H. Pooley, M.A., LL.B.
John Slater, F.R.I.B.A.
George Sutton.
Charles B. L. Tennyson, C.M.G.

Professor John Millar Thomson, LL.D., F.R.S.
Sir Alfred Yarrow, Bt., M.Inst.C.E.

TREASURERS:

William Henry Maw, LL.D., M.Inst.C.E.
Alan A. Campbell Swinton, F.R.S.

SECRETARY:

George Kenneth Menzies, M.A.

On the motion of the Chairman, a vote of thanks to the Scrutineers was carried unanimously, and duly acknowledged by Mr. Julius Garrat.

SIR HERBERT JACKSON, K.B.E., F.R.S., proposed a very hearty vote of thanks to Mr. Alan Campbell Swinton, not only for his conduct in the Chair that day, but in appreciation of the valuable services he had rendered the Society during the past year, as Chairman of the Council. He felt sure he was voicing the feelings of everybody in saying that the Society was exceptionally fortunate in its Chairman. He had always taken a warm interest in the work of the Society, and it would be difficult to find a more enthusiastic Chairman.

MR. CARMICHAEL THOMAS said he had very much pleasure in seconding the vote of thanks so eloquently moved by Sir Herbert Jackson.

THE CHAIRMAN, in acknowledging the vote of thanks, said he had tried to do his best. The work of the Society was really very interesting to him as it had so many different sides. His career of course was principally scientific, but some of the subjects dealt with before the Society had been somewhat of an education to him, and things had been brought to his notice which otherwise he would not have thought of. He hoped the Society would weather its difficulties; it was doing valuable work, and it had been a great pleasure to him to act as its Chairman.

The meeting then adjourned.

OBITUARY.

SIR HERBERT BABINGTON ROWELL, K.B.E., M.Inst.C.E., M.I.N.A.—The death of Sir Herbert Babington Rowell took place at Reedsmouth House, Northumberland, on June 23rd. He was born in 1860, and educated at Mill Hill School and in Switzerland. Entering the ship-building industry, he became Chairman of the well-known firm, Messrs. R. and W. Hawthorn Leslie and Co., Ltd. He was President of the Shipbuilding Employers' Federation, 1912-14; President of the North-East Coast Institution of Engineers; and Vice-President of the Federation of British Industries. He was elected a Fellow of the Royal Society of Arts in 1917, and in the following year was created a K.B.E.

SIR ROBERT NATHAN, K.C.S.I., C.I.E.—Sir Robert Nathan, who died on June 26th, at the age of 54, was a son of the late Mr. Jonah Nathan, of Pembridge Square, W., and the youngest of four brothers distinguished as public officials. One of these, the late Sir Nathaniel Nathan, was a Judge of the Supreme Court, Trinidad, and afterwards Chief Justice of that colony. Another, the Right Hon. Sir Matthew Nathan, is at present Governor of Queensland. The third brother, Colonel Sir Frederic Nathan, formerly occupied the post of Superintendent of the Royal Gunpowder Factory at Waltham Abbey, and is now Power Alcohol Investigation Officer to the Fuel Research Board. Educated at St. Peter's College, Cambridge, Sir Robert passed the I.C.S. examination in 1885, and was posted to the province of Bengal. After serving as a district officer for some years, he was transferred to the Imperial Government as Officiating Under Secretary in the Finance and Commerce Department. He was Private Secretary to the Viceroy during Lord Curzon's second Viceroyalty, and for a short portion of Lord Minto's. He was several times selected for special duty and other positions he successively filled included those of Commissioner, Dacca Division, acting Chief Secretary to the Government of Eastern Bengal and Assam, and Member of the Board of Examiners, Bengal. He retired towards the end of the year 1914. Early in the War he was an interpreter to the Indian troops at the front, and later was engaged on very important "secret service" namely, the tracking down of enemy and anarchical conspirators. It was due to him that the plot devised in Switzerland with German money, to assassinate the heads of the Allied nations was frustrated. He also unearthed in the United States, the German agents employed to destroy munition ships and munition factories. He was elected a Fellow of the Royal Society of Arts in 1920.

WILLIAM LAWRENCE SMITH.—Mr. William Lawrence Smith, whose death at the age of seventy-six, took place at his residence in Portman Square, on May 24th, was elected a Life Member of the Royal Society of Arts in 1901. A native of Cumberland, he settled in London, and in the year 1876 founded the firm of Messrs. Stapley and Smith, of London Wall, and soon became one of the most widely known members of the textile trade.

Mr. Lawrence Smith was a keen sportsman, being an excellent shot and an enthusiastic fisherman. He was also a generous supporter of many charities.

NOTES ON BOOKS.

LUBRICATING AND ALLIED OILS: A Handbook for Chemists, Engineers and Students. By Elliott A. Evans. London: Chapman and Hall, Ltd. 1921. 9s. 6d. net.

This handbook is a new volume of Messrs. Chapman & Hall's "Directly Useful" series, a series in which difficulties inherent to the sentiment of making a technical book "directly useful" have hitherto been overcome with marked success. An Editorial note on page xi. of the volume now under notice sets forth that the directly useful character must be wedded to that proper amount of scientific treatment which alone will satisfy the inquiring mind. Notable instances of the sterling value of works in the present series are afforded by Leggett's Wireless Telegraphy, and Aeroplane Design of Andrews and Benson.

We regret the necessity of suggesting that Mr. Evans's book now under notice fails quite to reach the high standard of the series taken as a whole, but, on the other hand, special, and perhaps insurmountable, difficulties may much limit an application the directly useful principle in the present case.

The scope of the work is, according to the Foreword, to lay bare the fundamental considerations in the selection of a lubricant. Turning to page 111, we find notes on Motor Car Engines, and a final sentence as follows:—"Owing to the large number of makes of engines, a tabulated list of standard makes is given, with the lubricant recommended for each make." Next follows a tabulation of nearly 200 cars or engines with a recommended oil or mixture for each, the recommended lubricant being in each case a commercial or proprietary grade as supplied by Messrs.——— and Co., Ltd. It is not for us to question any special merits of the proprietary lubricants which are indicated, but bare *ex cathedra* dicta of this character are usually regarded as outside the scope of ordinary technical handbooks, as published for sale.

Various historical notes, ranging in light touches from the fate of Lot's wife to James Young, are included in Mr. Evans's book; and a chapter on Oil Refining concludes with interesting references to recent proposals for the use of liquified sulphur dioxide as a depurating agent. The yield of oil from the liver of the shark appears to be somewhat surprisingly large, to judge by the particulars given on page 10, and some of the less known fish oils seem to possess valuable qualities.

Methods for the chemical and physical testing of oils are treated of, and as an accurate and carefully performed determination of the specific gravity of a fatty oil (as also of its separated fatty acid) affords highly important *prima facie* indications or suggestions as to source, quality, admixture, fraud or adulteration, one may expect to find a detailed account of the latest and most recondite methods of dealing with the specific gravity aspect; and this more especially as on the title page the work is stated to be for chemists. As a matter of fact, the recommendation to use the old form of stoppered specific gravity bottle as against the Sprengel tube, and the failure to treat of the many side issues for ensuring really accurate and good work, makes this portion of but little value to the professional chemist. The author may be fully justified from one point of view by his reference in the preface to a "not-too-technical" book; but nothing short of the latest, fullest, and best technics will be of service to the chemist in so delicate a matter. As an illustration, we may point out that there may be 802 isomeric tridecanes, possibly all differing in specific gravity or oxidisability, and any of these may perhaps be present in a refined petroleum lubricating oil.

We are inclined to think that, owing to the nature of the subject matter, in which there may be highly recondite conditions, both as to the agent aspect (lubricant) and also as to the patient aspect (machine), that any considerable application of the "directly useful" principle as ordinarily understood is impracticable. The nearest which we can suggest as a "directly useful" book in relation to a difficult subject like the present is one of the larger handbooks reduced to the form of a skeleton, but with every detail lightly touched on so as to serve as a reminder to the person who is really expert. Such a book, in fact, as Hooper's Physician's *Vade Mecum*; valuable, very valuable, to the experienced practitioner, but dangerous to the sick person if used by the unskilled.

To summarise our impressions. In relation to a technic with rather narrow ramifications of mode, like soldering, the use of the microscope, arithmetic, glass blowing, or wireless telegraphy, the "Directly Useful" system of instruction is practicable and expedient, but not so in the case of a technic so complex as that of lubrication. Yet nature gives many compensations and affords to some a power of mental integration analogous to that by which Newton, without data of which he was conscious, divined or "guessed" a near approximation to the specific gravity of the earth. Quite apart from Mr. Evans's known skill as a laboratory worker, we believe he can mentally integrate conditions in relation to his own technic, and place a lubricant appropriately; but this is something not to be taught, being rather of the nature of a grace, an inspiration, or an instinct, a quality which every notably successful worker must possess in greater or less degree.

Mr. Evans has made an interesting effort, and although he may not have fully realised his own aim, he has produced a book which should be of service on the shelves of the chemist, the engineer, and especially the person of discursive habits in study.

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FRIDAY, JULY 15, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

CHAIRMANSHIP OF COUNCIL.

On Monday, July 11th, at their first meeting in the new session, the Council re-elected Mr. Alan A. Campbell Swinton, F.R.S., Chairman for the ensuing year.

PRESENTATION OF THE SOCIETY'S ALBERT MEDAL TO PROFESSOR FLEMING.

The Council of the Royal Society of Arts attended at Clarence House, on June 27th, when His Royal Highness the Duke of Connaught and Strathearn, K.G., President of the Society, presented to Professor John Ambrose Fleming, D.Sc., F.R.S., the Albert Medal of the Society, awarded to him "in recognition of his many valuable contributions to electrical science and its applications, and specially of his original invention of the thermionic valve, now so largely employed in wireless telegraphy and for other purposes."

The members of the Council present were: Mr Alan A. Campbell Swinton, F.R.S. (Chairman); Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Lord Blyth; Sir Thomas J. Bennett, C.I.E., M.P.; Sir William H. Davison, K.B.E., D.L., M.P.; Sir Robert A. Hadfield, Bt., D.Sc., F.R.S.; Major P. A. MacMahon, R.A., LL.D., Sc.D., F.R.S.; Dr. William H. Maw, M.Inst.C.E.: Hon. Richard Clere Parsons; Lord Sanderson, G.C.B., K.C.M.G.; Mr. John Slater, F.R.I.B.A.; Mr. Carmichael Thomas; with Mr. G. K. Menzies (Secretary of the Society), and Mr. S. Digby, C.I.E. (Secretary of the Indian and Colonial Sections).

INDIAN SECTION.

A Meeting of the Indian Section Committee was held on Wednesday, July 6th.

Present—Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Sir Charles H. Armstrong; Sir Thomas J. Bennett, C.I.E., M.P.; Sir M. M. Bhownaggree, K.C.I.E.; Sir George C. Buchanan, K.C.I.E., M.Inst.C.E.; Mr. David T. Chadwick, C.I.E.; Mr. William Coldstream, B.A.; Mr. Laurence Currie, M.A., J.P.; Sir Frederic W. R. Fryer, K.C.S.I.; Sir Henry M. Evan James, K.C.I.E., C.S.I.; Major-General Beresford Lovett, C.B., C.S.I.; Mr. N. C. Sen, O.B.E.; Dr. J. A. Voelcker, M.A., F.I.C.; Mr. N. N. Wadia, C.I.E., and Colonel Sir Charles Edward Yate, Bt., C.S.I., C.M.G., M.P., with Mr. S. Digby, C.I.E. (Secretary of the Indian and Colonial Sections).

COLONIAL SECTION.

A Meeting of the Colonial Section Committee was held on Tuesday, July 5th.

Present Major Sir Humphrey Leggett, R.E., D.S.O., in the Chair; Sir Charles H. Bedford, LL.D., D.Sc.; Mr. Byron Brenan, C.M.G.; Sir Edward Davson; Mr. W. L. Griffith; Lord Sanderson, G.C.B., and Mr. Carmichael Thomas, with Mr. G. K. Menzies, M.A. (Secretary of the Society), and Mr. S. Digby, C.I.E. (Secretary of the Indian and Colonial Sections).

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

Friday, June 10th, 1921.

Sir William D. Sheppard, K.C.I.E., Member of the Council of India, in the Chair.

The Chairman, in opening the meeting, said that Sir George Curtis had for five years held the high office of Executive Councillor to the Governor of Bombay, and Bombay owed it to him—as the Governor himself (Sir George Lloyd) had stated in the Legislative Council—that the schemes which would be detailed in the paper had been brought into operation and were being carried on with great and continuous vigour.

THE DEVELOPMENT OF BOMBAY.

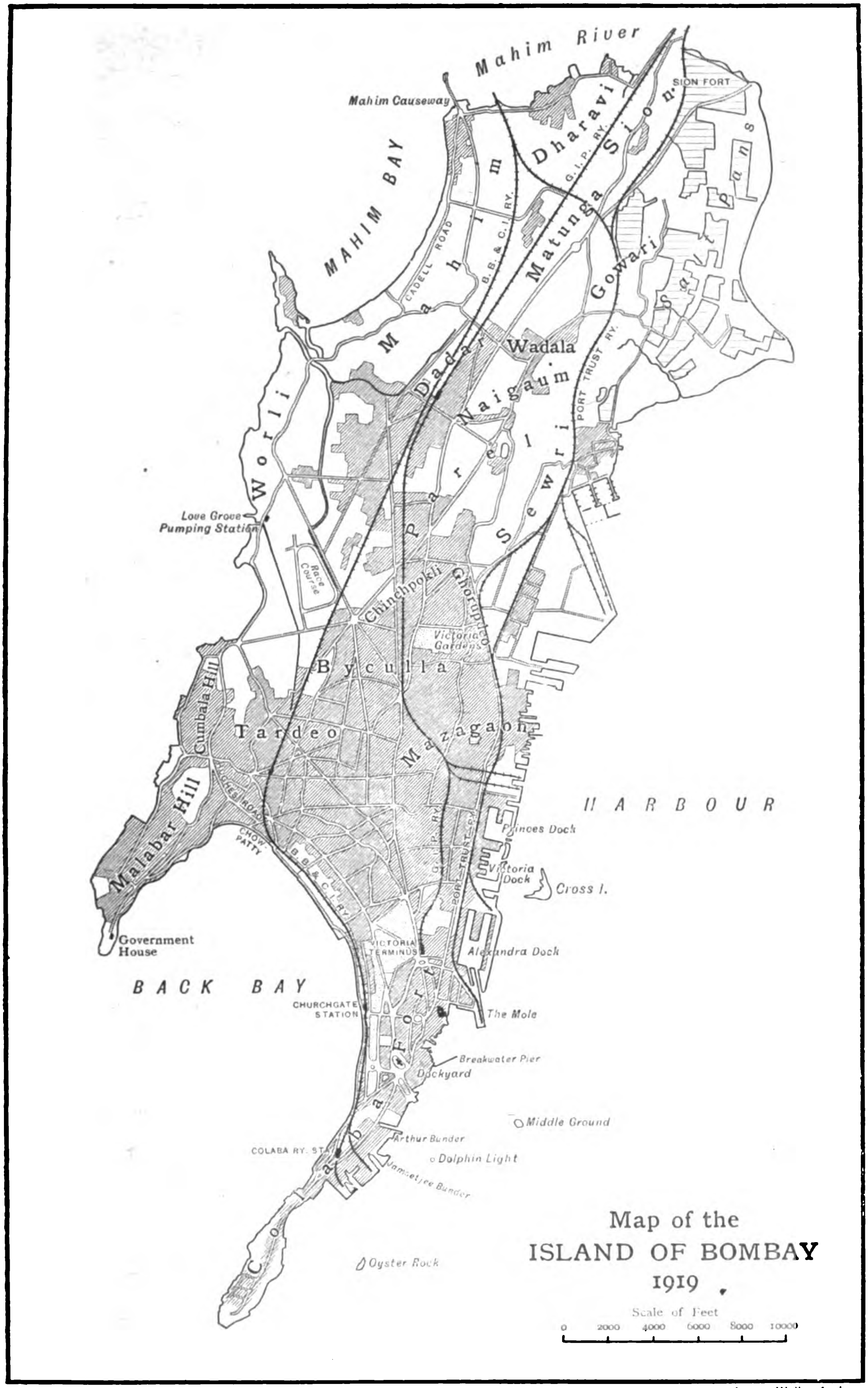
By Sir George Curtis, K.C.S.I.,

Member of the Bombay Government, 1916-21.

The origin of the paper which I am about to read here was shortly as follows. The city of Bombay has for many years suffered from congestion and there has been a marked shortage of housing accommodation, especially for the working classes. During the war, the mill industry was extremely prosperous, and owing to this cause and the general increase in the demand for labour, a large number of workmen flocked into the city from country districts. In fact, it is calculated that in this way the population increased by 25 per cent. This large accession to the population made the demand for housing among the labouring class even more acute than before, while the growth of wealth among the upper classes stimulated a demand for residences of a more expensive kind. After lengthy discussions it was decided to supply the deficiency in the dwellings required for the working classes by direct Government action. A scheme was drawn up to supply 50,000 tenements at a total cost of 5 crores of rupees, the loss on this scheme being met by a town duty of Re. 1 on every bale of raw cotton coming into Bombay for export overseas. A second measure, calculated to reduce congestion in the southern portion of the Island and supply residential accommodation for the higher classes was that for the reclamation of Back Bay. Thirdly, an extensive programme of improvements, affecting more specially the north of the island, was arranged for through the agency of local bodies, namely, the Municipality, the Improvement Trust and the Port Trust, funds for the purpose being supplied by a loan raised by Government. Fourthly, a special department of Government was formed charged with the control and execution of schemes of development generally, not only inside the city, but more particularly in the adjoining Island of Salsette. The rough estimate of the cost of these measures was thirty crores of rupees. In order to give effect to the proposal to impose town duty on raw cotton, it was necessary to amend the Municipal Act. A Bill for this purpose was introduced in the Legislative Council by the Governor, who made a lengthy speech outlining the whole policy of Government. Owing to the necessity of preventing speculation in land, great secrecy in the plans of Government was essential, and when his Excellency placed the proposal before the Council, it took both the Council and the public by surprise. Accordingly it was decided to start a propaganda explaining exactly what the various projects were, and the paper which I am about to read forms a part of it. It was read on the first occasion before the members of the Legislative Council and subsequently on several occasions before the members of the Bombay Municipality and prominent men in financial and industrial life of Bombay and Poona. It was translated into Marathi and Gujarati. Eventually the Bill, after consideration by the Select Committee, passed through the Legislative Council without a dissenting voice. A Development Loan was placed on the market in Bombay which yielded the magnificent sum of £9,389,000. I shall endeavour in this paper to outline what the policy of the Government is. The first part of the paper is historical, the second deals with projects for the development of the city and island of Bombay proper, the third with the extension of the port of Bombay, the fourth deals with the project of Greater Bombay, and the fifth with finance.

I am compelled at the outset to give you a short history. The fact is that the Development Committee of 1913, presided over by Sir Claude Hill, laid down—quite rightly in my opinion—that the pivot of all schemes of development in Bombay must be Colabo Terminus. Should it remain or should it be moved? They decided that it must remain. We have decided, and the Secretary of State has accepted our opinion, that it must go. I propose to explain the reasons why. It is all important to remember that Bombay island was originally a conglomeration of seven islands. Beginning from the south, these were; Colaba, Old Woman's Island, the Central Island containing the Fort and Malabar Hill, which latter was separated from the fourth island by the creek at Umerkhadi. North of the fourth island was the Island of Parel, on the north of which again was the island of which the Sion Fort was the centre. Turning to the west through the cluster of cocoanut trees called Mahim we come to the Island of Worli.

The whole of the centre of the island was inundated every year by the sea breaking



Emery Walker Ltd. sc.

through the Vellard or Dam put up by Governor Hornby on the west of the race course; between the Old Woman's Island and the Fort there was a considerable area of open sea passable only at low tide. The anchoring ground of the trading vessels was off the Fort. Round the walls of the Fort a considerable area was kept clear in order to give to the guns full play. The Dockyard was to the south of the Fort immediately under its protection.

Captain Dickinson's map of Bombay, which was completed in 1816, and is the next in historical order, shows that there was even then a considerable gap between the main island and the Old Woman's Island. To the north of the main Fort there was then the outlying Fort St. George which was situated on the site of the existing European General Hospital. North of the Fort St. George again there was a large deep bay where the sea flowed over what is now the site of Frere Road, the Bombay, Baroda and Central India Railway goods-yard and the Victoria Dock. On the western side the sea came up to the burning ground on Queen's Road, and further north submerged the area on which the New Queen's Road and the whole of the Improvement Trust Estate at the foot of the Malabar Hill now stands.

The next important stage in the development of Bombay is the concentration of the cotton presses and location of the cotton market on Old Woman's Island, or as we now call it, Colaba. This is an important point in the history of the development of South Bombay. Bombay, as we all know, is the biggest market for cotton in India, and the trade in cotton began to assume large proportions in the early years of the 19th century. At that time all cotton arrived in an unpressed state by sea from Surat, Broach and Dholera to the north and Kumta to the south. The port of Dholera has long been silted up.

The port of Kumta is in Kanara, a district which grows no cotton, and the cotton exported from Kumta was grown almost entirely in the Dharwar district. With the opening of the Southern Maratha Railway in 1886 the export of cotton from Kumta entirely ceased. We still, however, find Dharwar cotton described as Kumtas in our daily price list. The same remark applies to Dholera type of cotton which is brought by rail from Gujarat. All cotton that was brought into Bombay in the early years of that century was landed at the Fort Jetty and dealt with in the Bombay Green, which corresponds roughly to the Elphinstone Circle.

A few rough presses were erected to reduce its bulk. The area, however, was found inconvenient and in the early forties the Cotton Green was removed to a large site which corresponds roughly with the area adjoining Wodehouse Road, Wellington Mews and the Admiral's Bungalow. At the same time various bunders, such as the Arthur Bunder, the Jamsetjee Bunder, were opened on the Old Woman's Island, and, what is more important, a number of powerful presses were erected, worked by 200 men each.

The effect of the erection of these presses on the general development of the island has been most remarkable. In the late fifties and early years of the sixties the construction of the B.B. and C.I. and the Great Indian Peninsula Railways was commenced. And both these companies as their lines approached Bombay made desperate efforts to reach Colaba in order that the large consignments of unpressed cotton brought down by them might be pressed on Old Woman's Island with a view to export abroad.

In this connection the map of Bombay in 1864 is of very great interest. It shows two hollow bays, one on the east of the island just north of the Fort St. George, and another on the west, where the Gymkhanas on the Kennedy Sea Face now stand. To both of these are long stories attached. As regards the bay on the east a proposal was put forward in the early sixties to reclaim it, and a company known as the Elphinstone Land Company was formed for this purpose. The company under its agreement was bound to make over to Government an area of 100 acres which was wanted for the purposes of the G.I.P. Railway Company.

It was further allowed to reclaim 250 acres for the construction of bunders for the convenience of the trade to and from the native town. The 100 acres were completed and handed over; with the result that the G.I.P. Railway was enabled to enter the city and establish their terminus at Wadi Bunder at the spot about a quarter of a mile north of the existing terminus. The area of 250 acres reclaimed on the Company's account was shortly after completed and proved to be highly remunerative, with the result that the shares acquired an

inflated value. On the collapse of the Back Bay Reclamation Company in 1865, to which I shall refer hereafter, there was a general fall in values which brought the company into difficulties.

In addition to this it was found inconvenient that a private company should be in the position of levying dues on the whole trade of the native town. Consequently the project of constituting a Port Trust was taken in hand, and the property and privileges of the Land Company were transferred to the Trust on an undertaking that the capital of the Land Company should be converted into 4 per cent. Indian Stock of equal face value and that the Trust should be responsible for payment of interest on the capital. The 220 lakhs which constituted the capital of the company represents the nucleus of the existing Port Trust debt. This was the beginning of reclamation on the east of the island. The story of reclamation on the west is a longer and sadder one.

The B.B. and C.I. Railway did not, as one would suppose, begin operations in Bombay. The first section completed was from Baroda to Bulsar and the railway proceeded south until it reached Bassein. There it was first proposed, in order to avoid the bridging of the creek, to take the line along the north side to Parsik north of Thana and bring it into Bombay on the western side of the island. Eventually, however, the creek was bridged and the railway reached Bombay in the early sixties with the terminal station somewhere on the Flats. But this arrangement did not satisfy the railway. They were bringing down large quantities of cotton, and they were desperately anxious to reach the presses at Colaba. Consequently when the Back Bay Reclamation Scheme was formed for the filling up of 1,500 acres in Back Bay the railway promised to co-operate in every possible way.

Their co-operation was important, for in those days there was no question of dredging the soil from the bottom of the sea for reclamation purposes and merely covering it with murum. Every ounce of filling had to be transported by rail. The reclamation company, as I have said, was formed in 1864 at a time when, owing to the American War and the great increase of wealth thereby caused, the whole of Bombay was in a fever of speculation. The original idea was to reclaim 1,500 acres, of which 300 were to be given to Government free of charge. The remaining 1,200 were to be developed by the company. Government, in return, originally undertook to take up 400 shares of Rs. 5,000 each.

Owing to the speculative mania the value of the shares, which was originally £500, rapidly rose until more than £3,000 were paid for each share, and when the Secretary of State ultimately vetoed Government taking up shares in this private company, the 400 shares were sold for the sum of £1,060,000. A large part of this sum was placed on fixed deposit with the Asiatic Banking Company, which failed, and its failure brought the whole structure of credit, including the Bombay Bank, down in a crash. Meanwhile, however, the reclamation had been proceeding, the material for filling this bay being obtained by cutting the western side of the Cumballa Hill on the site where the Manockjee Petit Mill and other buildings in Tardeo are now situated. The existing steep slope of the Cumballa Hill is, of course, due to the removal of stone for filling up Chowpati, and the Sea Face.

When the crash came the reclamation seems to have reached more or less a point opposite the Hindu burning ground, and the railway material trains ran up to that point. The question of the permanent route of the railway was still undecided, and there were some who advocated what was known as the overland route down Girgaum Back Road.

Eventually, however, the railway were allowed to erect a temporary passenger station at Marine Lines, which was for some time selected as the permanent terminus of the line. The attraction of the cotton presses at Colaba, however, was still strong and the railway pressed for permission to take the line further south. The proposal met with a strong opposition on the part of the authorities. To them it seemed unthinkable that a steam engine should be allowed to draw a train on lines laid between what were then the new public offices and the sea. And it can be gathered that when first permission was granted for trucks to be moved across the maidan, it was given on the understanding that they should be hand-shunted or drawn by horses.

Eventually permission was given to use steam engines, but these were not allowed to cross the maidan after 2 p.m., and when the railway company complained to the

Secretary of State, the Bombay Government replied that their request was unreasonable, "that steam engines would never be allowed near Rotten Row or Hyde Park Corner. Why should they be allowed in Bombay ?" When the hours were eventually extended, the railway company of its own accord offered to stop their goods traffic between 5 and 7. The scene of the controversy was then shifted to the site of the new station at Colaba. The railway company in addition to access to the cotton presses, were anxious to reach the Gun Carriage Factory and construct their terminus there. (The factory had recently been closed and shifted to Kirkee.) This was done with the object of obtaining their stores from the bunder on the eastern side.

The prolongation of the railway line to the Gun Carriage Factory, however, involved taking the line across to the main Colaba Causeway, and this the then Municipal Commissioner, Mr. Crawford, stoutly opposed. In its stead, he proposed that a new road should be built from the Wellington Fountain towards Colaba, and that the passenger terminus of the railway should be located on the west of the Old Woman's Island in close proximity to the Victoria Press. In the end Mr. Crawford triumphed, and the passenger terminus was located on its present site. It was to reach this site that the existing Wodehouse Bridge was built. The railway further were allowed to build sidings on the cotton green and to extend their line for the purpose of stores only on to the Gun Carriage Factory. An attempt to extend their sidings across the Causeway on the Apollo Reclamation to the existing cotton yard was, however, successfully resisted.

The G.I.P. Railway, in the meanwhile, had been making strenuous efforts to reach Colaba. They at one time put up proposals for the construction of a horse tram leading from Wadi Bunder to the Cotton Green. They complained of the trouble and the expense involved in carting the unpressed cotton from their yard to the presses. The contract rate at that time, it may be noted, for carting cotton to the Green was Re. 1-4-0 per ton. (Rather different from what it is nowadays.)

Eventually, however, the company were given running powers over the B.B. and C.I. Railway, and thus the cotton of both companies found its way to Colaba. The importance of these remarks lies in the twist which the location of the presses has given to the development of railways in the island. The construction of the line from Church Gate south of the Colaba terminus was entirely due to the location of the cotton presses on the Old Woman's Island. Had hand presses existed for handling cotton at the more northern point in the island, say Mazagon, quite probably the Colaba Terminus would never have been built. The question whether this terminus should be retained has been for some time the pivot on which the whole of the develop- of Bombay Island has turned. As it was, the presses were an overpowering attraction. But for the presses, the railway would never have passed Grant Road, there would have been no Reclamation and no Kennedy Sea Face.

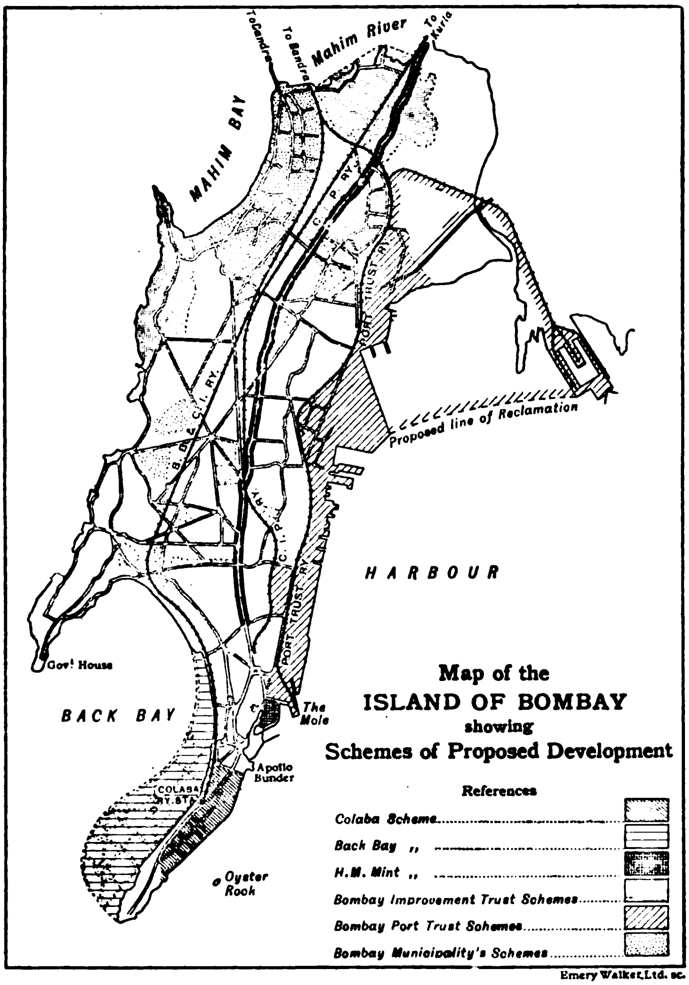
In 1910 it was decided by the Port Trust, who are the owners of the existing Cotton Green, that it would be to the interest of the city if the Cotton Green were to be removed to a more northerly point in the island adjacent to the docks and the larger mills so that cotton could be removed for local manufacture or exported to foreign countries without the necessity of taking a long journey by cart through the business quarters of the city. The land necessary for the Green has been allotted and the arrangements for its equipment are in course of being made.

It is hoped that the Green will be ready for the reception of the trade in 1923 or 1924. The removal of the Cotton Green from Colaba will, of course, result in the total cessation of the goods traffic and a very large reduction in the passenger traffic. This has led to a further examination of the question with the result that the Secretary of State, after careful consideration, has decided to avail himself of the option secured when the erection of the original terminus was sanctioned, and has given notice to the company to remove their line south of Church Gate. Under this arrangement the local service will run as far as Church Gate, while Grant Road will be the main terminus station of the long distance traffic. The arrangement is, perhaps, not ideal, as, in the opinion of modern traffic experts, it is considered unsound to lead local trains into a dead end as at Church Gate.

But it is hoped eventually that the line may be sunk in a tube west of Charni Road and taken to the western side of the island underground at Colaba, returning in a

circular direction on the east either to the Victoria Terminus or to the terminus of the Port Trust Railway in the docks. If this were to be completed there would then be a complete inner circle from Bandra, in one direction *via* Grant Road and returning *via* the Victoria Terminus on the Mahim chord. As all traffic experts unite in recommending that local service in large cities should run on a circular system, this would probably be an ideal arrangement.

I shall now proceed to deal with the schemes in detail. The two Colaba schemes are—first: the Colaba west or Back Bay Reclamation Scheme; second: the Colaba east, at present covering about 150 acres. These schemes require some explanation. In my earlier remarks I referred to the proposal which was made in the year 1860 to reclaim an area of 1,500 acres from Back Bay, of which only 300 acres was completed. Apart from financial difficulties, I doubt



Map of the
ISLAND OF BOMBAY
showing
Schemes of Proposed Development

Emery Walker Ltd. sc.

I will now pass on to the map of Bombay as we know it at present. In the acompanying sketch the various projects in hand or contemplated are shown in different shadings: The double thick line shows the main eastern avenue which is complete from the Mahim chord line on the north to within a few yards of the Crawford Market.

whether the whole area would ever have been completed, for the reason that the filling was all solid stone and murum and had to be brought in by rail or barge.

Since 1905 various plans have been put forward for completing the reclamation with a certain modern type of dredger so designed as to cut up the soil in the bottom

of the harbour and convey it through pipes supported on pontoons. Through these pipes the detritus can be boosted over considerable distances and then discharged, so as to form a new reclamation. In all projects put forward in recent years for reclamation of Back Bay, the use of dredgers has been a prominent feature. In the proposal of 1912, which received a considerable amount of support from engineering authorities, it was proposed to place a dredger in the harbour and discharge the detritus into Back Bay by means of seven pipe lines. One of these pipe lines began at Ballard Pier and was taken down Church Gate Street, towards the sea at Church Gate Station. It is obvious that this plan was open to grave objection.

The latest plan contemplates the use of three pipe lines only. The dredger to be employed will be of an improved type and will be the largest of the kind yet manufactured. The order for it has been placed with the firm of Messrs. Simons, of Renfrew, and the cost will, it is expected, amount to £600,000. The dredger will work mainly on the area near Oyster Rock, and will, it is hoped, bring up suitable soil.

When this is done it will be necessary to superimpose a filling of hard murum. For this purpose, it is proposed to take off a siding from the B.B. and C.I. Railway at Charni Road and carry the material in trains down to a point opposite the Marine Lines Station. From this point a gantry will be constructed, which will enable waggons to deposit the murum at the spot required. The amount required represents a load of four trains per night, which, it is hoped, the Railway Company will be able to supply. Pending the completion of the large dredger a small dredger has been purchased and will begin operations from the western end. It is hoped that with two dredgers working it may be possible to complete the reclamation within six or seven years.

The engineers for the work are Messrs. C. S. Meik and Buchanan, who are a firm with great experience in reclamation projects, and the Resident Engineer is Mr. Lewis, whom Government have been fortunate enough to secure from Burma. There are one or two features in the scheme to which I should like to draw attention. It is clear that the removal of the railway south of Church Gate will add enormously to the amenities of the reclamation. Otherwise, there would have been four lines of rail running into Colaba Terminus. For this purpose it would have been necessary to widen considerably the existing Wodehouse Bridge.

Furthermore, two other bridges would be necessary. If the railway were to be allowed to remain in its present position, it would be necessary to provide access to the main avenue of the reclamation by a level crossing. This, of course, could not be allowed as a permanency, and it would be necessary to provide a bridge, the slopes of which would have to be taken off somewhere at the Band Stand. A further bridge would be necessary at Church Gate to provide access to the public park north of the reclamation.

A second point to be noticed is that a large area will be made available for residential purposes by the removal of the Cotton Green and Railway Yard, and the filling up of Arthur Bunder. The scheme for the development of this area is not yet ripe, but with the removal of the Wodehouse Bridge it should be possible to prolong the existing Queen's Road towards Colaba up to a point where it will meet Colaba Causeway. The latter road will then be widened to 100 feet.

Details of the Improvement Schemes.

I now turn to the Improvement Trust and Municipal Schemes. Passing over those already in existence, I come, first of all, to a small but very useful scheme near the Race-course. An arrangement has recently been come to between the Turf Club and the Municipality by which the latter advances the sum of £100,000. This sum is to be employed in the construction of a park measuring 26 acres at the angle between Clarke Road and the Hornby Vellard.

The position of the Race-course is to be altered, the major axis being shifted about 60 degrees, so as to run east and west. The ground inside the new course is to be converted into a Public Park and Golf Course. The improvement will make available a large area on the north of the existing Course, in which it may be possible to place institutions where fresh air and proximity to the sea are of prime importance, for instance, a Children's Hospital.

I move north, next, to Love Grove Pumping Station, so well known to all of us. It would perhaps be rash to anticipate what the decision of the Municipality will

be with reference to the future drainage of the Island. But it is an open secret that a great expert who recently visited Bombay has recommended the removal of the Pumping Station to the eastern side of the island, retaining only a small station large enough to deal with storm water.

If effect is given to this proposal, as all who know the area devoutly hope it will, the serious nuisance arising from the present conditions will be entirely removed, and the whole area at Worli north of the Pumping Station will at once become available for residences of a high class. It must have been in hopes of some arrangement of this nature that the Improvement Trust designed their Worli scheme, which covers 1,350,000 square yards.

This scheme, it should be noted, provides for three different classes of houses; the richer class on the sea face, the middle class on the main road, and the working class on what is now the rice land in the neighbourhood of the mill. The scheme, as now contemplated, is expected to cost £1,760,000, but there is every promise that the expenditure will yield a very large return. Proceeding north, the next scheme is the Mahim scheme undertaken by the Bombay Municipality with the financial support of Government. The scheme provides for two main avenues running north and south, one of which is on the high road to completion—Cadell Road from Worli to Bandra Causeway. It is hoped eventually to widen the Lady Jamsetjee Road to 100 feet and prolong the southern end to meet the De Lisle Road at the top.

Provision is made for a central park in the middle of the scheme with a frontage on the bay and for another park on the southern end of the area. The minor roads necessary for development will be 35 miles in length. It is anticipated that it should be possible to house approximately a population of 250,000 on this area.

Proceeding further north and crossing the railway line, we come to an area which is now occupied by the tanneries in Dharavi. This area covers 2,266,000 square yards, and the Improvement Trust proposes to convert it into a salubrious garden suburb, the tanneries being removed to sites in Trombay. An important feature of the scheme will be the provision of an esplanade open to the western breezes. The cost of the scheme will, it is estimated, be £1,520,000.

Proceeding further to the east, we come to the Sion-Matunga Scheme. The area included in this scheme amounts to 7,800,000 square yards, and the development is now proceeding. There is every sign that the return will be extremely profitable. Proceeding south along the eastern avenue, we come to the well-known Dadar-Matunga Scheme, with which most of you are familiar. The area comprised here is 720 acres, and the building plots number 800. Sales of this land in recent years have been unusually profitable, and the financial position of the scheme at the present moment is shortly as follows:—Expenditure, £570,000; Revenue, £45,000. The return is approximately 8 per cent.

It is often said, however, the Improvement Trust has confined its energies to making provision for the upper middle classes, and that the working classes have been severely left alone. The statement is not true as regards the schemes which I have been discussing, as in every one of these there is provision for locating tenements for working classes on the back lands. But I now come to a scheme which is intended for working classes and lower middle classes and no one else. I refer to the Sewri-Wadalla Scheme. The area of this is some 320 acres.

An important point in connection with this scheme is the Port Trust Harbour Branch Railway running along the eastern boundary. It is in contemplation to make provision for the running of trains on the Port Trust Railway directly into the Victoria Terminus. But owing to the war and the consequent delay in obtaining the necessary iron work, it has so far been impossible to effect this. When the connection is complete, however, the trains from Wadalla will reach Victoria Terminus and Sewri in something like 10 minutes. Persons, therefore, of the humbler clerk and peon class who take up their residences in this scheme will find it easy to reach their offices in the Fort. Some part of this scheme has been earmarked for quarters for Post Office and other Government servants.

I now skip a considerable distance, in order to complete my list and show the Church Gate scheme, which is now being carried out by the Municipality. It is expected that this will be carried out at a profit of no less than £330,000. The scheme provides for a broad street running from the Floral Fountain to the Town Hall and

a through road from Medows Street *via* Bruce Lane to Apollo Street, and for the construction of an island site on the Armenian Lane. Land on the island site has recently been sold at £137 10s. per square yard.

There remains a small scheme which will be useful in itself and may lead eventually to a larger one. This also is a Municipal scheme. The scheme contemplates the widening of the Dalal Street and the construction of a street between Apollo Street and Medows Street, which, it is hoped, will eventually reach up to the University Gardens. In order to facilitate the scheme Government made a grant to the Municipality of part of the Book Depot, charging only £10 a square yard. This meant practically the grant of something like £30,000 towards the scheme.

I have now exhausted the Municipality and the Improvement Trust, and will turn to the Port Trust. The question of the extension of the Docks has always been present in the minds of the Port Trustees. The question is a very difficult one owing to the necessity of providing accommodation for the constantly expanding trade of the Port. It seems only the other day that his Excellency the Viceroy, Lord Hardinge, opened the Alexandra Dock. But the accommodation then provided is now fully utilised, and the trustees have had to look round for some time past for a site where a new dock can be placed.

The report of the Development Committee of 1913 suggested that it might be necessary to place the new dock somewhere in the vicinity of the Sassoon Dock. I am not sure whether the suggestion had the support of expert opinion. But if it ever had, it will be a relief to all to know that it has been dropped, as the prospect of the heavy traffic to and from the dock passing through the Fort would have been appalling. The second plan which received considerable expert support, regarding which there was for some time an acute controversy among the advisers of the Trust, contemplated the provision of a new dock outside the existing dock wall opposite Cross Island. Here again the traffic problem was a difficult one.

The main Frere Road passing by the Docks is already terribly congested, and it seemed difficult to understand how it could accommodate traffic to and from another dock. Inquiries were accordingly set on foot, and it seemed possible to locate another dock at a site north of the existing Victoria Dock, but further enquiry showed that it would be difficult to do so owing to the fact that the channel is comparatively shallow, and the material at the bottom of the harbour is composed of solid rock. The cost of blasting out a channel 40 feet deep sufficient to take the vessels of modern size would have been prohibitive.

At this point Mr. Messent, late Chief Engineer, was placed on special duty to make further enquiries, and it is due to him that we have now before us the discovery of an epoch-making character, which is likely to have more far-reaching effects on the development of the City and Port than anything which has been done in the last half century. I should mention that the Port has already in hand the provision of a petrol pier close to Pir-Pao. It is proposed to pump petrol from the vessels which bring it into a pipe which will be led along the new road to be constructed between Pir-Pao across the salt works to a point near the oil installation at Sewri.

Work in connection with this pier shows the possibility of excavating from mud bottom a channel 40 feet in depth, which will enable vessels to pass on the eastern side of the Butcher Island to a new Dock to be constructed on the south-east corner of Trombay. Plans for a large dock of modern type at this point have been prepared and have, I understand, been recently passed by the Trust's consulting engineers in England.

The new dock will be connected with the Port Trust Railway by a line taken off north of the Wadalla Station. The necessary land has already been notified for acquisition by Government. The advantages to the city arising out of the discovery of this new area will be enormous. Until quite recently it was held that the space available for additional accommodation was exhausted. Now it is practically unlimited, and it will, it is hoped, eventually be possible to transfer to this neighbourhood the R.I.M. Dockyard at present located in the Fort.

The slopes of the Trombay Hill, which overlook the site of the new Dock and which have also been notified for acquisition by Government, will provide suitable and salubrious sites for residences of officials and labourers employed in the dock at very small cost.

Two new roads are to be constructed by the Municipality and the Improvement Trust to link up the area with Parel and Curry Road. The Manganese Depot and Iron Market Depot are also provided for on this area, which covers 583 acres.

The next scheme lies to the south, and comprises the new Cotton Depot under construction on the Mazagon-Sewri Reclamation. The area under treatment covers some 90 acres, and there is an additional 13 acres available for its extension on the north.

As I said, in my opening remarks, the provision of a Cotton Green in the north of the island is a preliminary essential to all schemes for the development of Bombay. The scheme provides for the construction of some 200 godowns, each of them with a capacity of 7,500 bales, or roughly a total storage of 1½ million bales.

In addition, there are some 200 jathas or open-air storage plots with accommodation for some 800,000 bales. Over 10,000 square yards have been reserved at the west end for the erection of merchant's offices and branch banks. The railway facilities provided will be of the most modern type. Thirteen stations are provided, those for the arrival being at the north and those for the departure at the south end. Each station will be 250 feet long with a siding capable of taking 10 waggons at a time. It is hoped that the new Depot will be ready by April, 1923, or, at any rate, before the end of that year.

Moving south again we come to the Ballard Estate, on which the erection of fine commercial buildings is now in progress. Adjoining this is His Majesty's Mint, originally completed about 1829. Much of the machinery and stock at the Mint has now become old and out of date, and it will be necessary in the near future to erect a new Mint with modern machinery of the latest type. The opportunity has now been taken by the Government of Bombay to press on the Government of India the possibility of removing the Mint to an area in the north or outside of the island, particularly having regard to the fact that the Mint employs a large number of labourers and staff, for whom there are no housing facilities in its vicinity.

If the Government of India agree, as they have indicated that they will, to the removal of the principal building, the military authorities who own Bombay Castle and the Arsenal next door have expressed their willingness on certain conditions to place their land at our disposal for development along with the Mint.

A further proposal now under discussion is the removal of the R.I.M. Dockyard. It is suggested, in view of the admitted necessity of the enlargement and re-equipment of the Indian Marine Dockyard, that this should be transferred to a site either in the vicinity of Trombay or, as was originally suggested, to Hogg Island, the former of which seems to be preferable. In the event of the transfer becoming possible an area of some 71 acres, which might be increased to 100 acres by reclamation, will at once become available for the provision of office and residential accommodation in the heart of the Fort.

I have dealt so far with the various schemes in progress or contemplated inside Bombay Island. I am now going outside, and in another map, I show the southern part of Salsette. The Development Committee in 1913 recommended that future mills and industrial institutions should be located in the north-east corner of the island. In the five years which have elapsed since their report was written, changes have taken place, and it is clear that the north-eastern corner will be largely required for residential purposes. Further, the cost of the land in that vicinity has risen so high as to make location of a mill there practically impossible.

Recognising this fact and realising that it is necessary for the future expansion of Bombay that a large area should be required and made available on easy terms, the Government of Bombay have recently notified for acquisition an area of 7,500 acres. The importance of this step cannot, in my opinion, be over-estimated. The island proper must shortly be overcrowded. Space is already wanted for the tanneries to be removed from Dharavi. More space will be required for slaughter houses, milch stables, for dirty and insanitary callings, and above all, for the location of new mills and other industrial enterprises.

The area near Trombay will provide, it is believed, an ideal site for this purpose.

The Trombay Hill will provide a magnificent site for the dwellings of the richer classes, while those of the middle and the lower can be located close to the mills and other places where they work. Land would be so cheap according to Bombay ideas that the space allotted for housing purposes

would be generous. Communications only require to be improved. It is already remarked that there will be a branch railway to the new Docks at the extreme south-east corner. In addition to this, there will be a direct road from Sewri to Pir-Pao. At the northern end it is in contemplation that the Municipal Kutchra Railway should be ballasted and converted into a proper passenger line, possibly extending to the sea at Thana Creek, which will provide communication along the whole length of the island. Eventually, it is proposed that the salt marshes between Bombay Island and Trombay should be reclaimed. Bombay will then cease to be an island.

Moving to the west, the next scheme of importance is the Powai Water Scheme. The Powai Lake was constructed by the Municipality in 1891, but it has practically been never made use of, and the impression has got abroad that the water is unwholesome. Enquiries were, however, made from experts of the highest reputation as to whether it would be possible to render the water suitable for human consumption. The reply was that the water could be effectually filtered.

Consequently negotiations were entered into by the Government with the Municipality, and owing to the willing co-operation of the latter body, an arrangement has been made by which the Municipality agree to erect a filtering installation of the most modern type and supply to Government 2,500,000 gallons per day. This water will be taken along two mains, one leading to Andheri and Versova and the other direct to Santa Cruz, and it is hoped eventually over Palli Hill to Bandra.

It should now be possible within a comparatively short time to supply the whole of this area with water of the first quality at a very cheap rate. The effect on the popularity of the area for residential purposes cannot fail to be considerable. The cost of the pipes owing to the effects of the war amounts to no less a sum than £3,500,000.

Moving further west is another area notified for acquisition by Government. Of this the southern boundary, roughly speaking, is the new road shortly to be completed, which leads from Santa Cruz Station to Juhu Island. The northern boundary of the area is the road leading from Andheri to Versova. The area is at present useless as cultivating land. It is intended to take in hand at once the construction of an aerodrome north of Ville Parle which will enable aircraft to visit and depart from Bombay at all seasons of the year.

At a later stage it is proposed to utilise the murum contained in the hill for the filling up of the whole area, beginning from the south. This should make available a large area of land for housing purposes in the vicinity of Ville Parle and Santa Cruz Stations.

I will now return to the map of Bombay City.

It may be thought that I am drawing a fancy picture. But I am speaking of nothing which, if all goes well, is not practicable within 10 years. It will be quite possible then for a resident of Bombay to leave his office in the Fort and starting from the western end of the Colaba Reclamation, motor up the magnificent central avenue through the park at the north and along the Sea Road already under construction as far as Chowpatty.

Proceeding thence *via* Hughes Road, Breach Candy and Nepean Sea Road, he will travel on to the Vellard. There he will find 100 acres of park, and if it is not a race day, an excellent Golf Course. Proceeding north he will cross the storm water channel which will no longer have any terrors for him. He will turn half left on the Sea Face Road on the west of Worli Hill, move north around the promontory until he comes to the Mahim woods. He will then pass along a magnificent 100 foot road through the central Mahim Park to the southern end of the Mahim Causeway. He can, then, if he wishes, go north along a 100 foot road as far as Andheri. If he prefers to go east, he will travel along the Esplanade to Dharavi to a 150 foot Causeway at Kurla.

For his return home from that point he will have the option of two roads, either the main eastern avenue ending with the Crawford Market, or the main road through the Sewri-Wadalla Scheme connecting with the Frere Road and finishing up at Elphinstone Circle. Except along the latter part of his drive he would see nothing in the slightest degree sordid or repulsive, but houses of the best class in a city which ought to be the most beautiful in the world.

In my view the future is one of immense promise for the Municipality of Bombay.

After its amalgamation with the Improvement Trust, which must come shortly,

it will be the owner, in fee simple, of an area of approximately one-third of the whole island, and directly responsible for the management of the schemes in the north of the island, a return from which, if we may judge from the Dadar-Matunga Scheme, promises to be profitable.

The natural advantages of the city can hardly be disputed. What city in the world is there like Bombay, with its magnificent 20 miles of littoral, with a gravity water supply scheme delivering 90,000,000 gallons of water daily, and with the certainty of some 250,000 horse-power hydro-electrically generated being available in the near future? All that seems necessary at the present moment is to look far ahead and take a broad view. To my mind the time cannot be far delayed when the management of the large inhabited area within the confines of the Island will be too much for one body. And the difficulty will be even greater, as seems certain when the Municipality acquire properties for its own purposes in the Trombay area and elsewhere outside its borders. The new local body at Trombay is not likely to be as accommodating as that at Bandra.

The time cannot be far distant when portions of Salsette must come under Bombay control, and it is perhaps permissible to look forward to a Bombay County Council managing an area including Bombay Island and two-thirds of Salsette with Borough Councils subordinate to it in control of three or four divisions of the Island and localities which have already Municipalities of their own, such as Bandra, Kurla, Ghatkopar, and Santa Cruz. If this is realised now, it will be easy to effect the change when it becomes necessary.

Now it remains for me to explain how the whole of this very large scheme is to be financed. It is important to bear in mind that the programme consists of two parts. The first is of schemes with which Government is directly concerned. These are: The Back Bay reclamation, the housing of the working classes and the development of Salsette. The cost of the reclamation is expected to be five million sterling. In return for this sum, Government hope to secure at the end of seven years, four million square yards of building ground. Part of this will be ready in four years. It is beyond my province to suggest what the return per square yard would be some years hence. Recent sales, however, of land within half-a-mile of the area to be reclaimed show a return of £10 per square yard. Even assuming that the actual return secured would be only half of this, it is clear that the scheme is likely to be extremely profitable. For financial purposes, the next two parts of the programme, *viz.*, the housing of the working classes and the large development of Salsette, hang together, both being financed primarily from the town duty on raw cotton imported into Bombay for exporting overseas. The total number of bales of cotton imported into Bombay on average is 2,800,000. Roughly speaking, 1,700,000 are exported, while 1,100,000 are retained for consumption by the Bombay mills. The loss expected on the housing scheme, *i.e.*, the difference between rent received on the one hand and interest charged on the other, is expected to be 13 lakhs per year. It is calculated that the appropriation of this sum of 13 lakhs from the cotton duty will render it possible to meet the loss on the housing scheme and provide a Sinking Fund for the repayment of the loan in 50 years. The balance of Rs. 400,000 from the town duty levied on cotton exported will be allotted yearly for the development of Salsette. In the latter case, it is anticipated that the return will be extremely rapid and the expenditure of this sum will enable a great deal to be done. The second part of the programme relates to the schemes to be carried out by local bodies. The cost of these is estimated at present in the case of the City Improvement Trust 10 crores, the Municipality 8 crores and the Port Trust 5 crores. As regards the Improvement Trust, the financial position has changed in the most extraordinary way for good during the period of the war, the net revenue from the Trust's estates having trebled in that period, *viz.*, from 9.8 lakhs to 31.1 lakhs. The recent schemes of the Trust have yielded large profits and there can be no doubt that receipts from others now in contemplation will more than meet interest and Sinking Fund charges. In the case of the Municipality, as I have already mentioned, out of 2,800,000 bales of cotton imported into Bombay, 1,100,000 are consumed locally by the mills. The Town Duty on this amount will yield Rs. 1,100,000. This portion of the duty will be handed over to the Municipality to assist them in financing the many big schemes, such as the triplication of the Tansa Main, the remodelling

of the drainage arrangement, including the removal of the Love Grove Pumping Station, the provision of additional markets, hospitals and the realignment of roads. The Municipal Act has recently been amended to empower the Municipality to raise their limit of general taxation from 12 per cent. to 17 per cent. With the additional revenue secured from the share of the cotton duty, from the rise in the rate of general taxation, from the increase in the rateable value of property and the large extension of buildings in the island, it is anticipated that they will secure an extension of revenue which will enable them to meet the cost of the many ambitious projects now in front of them. In the case of the Port Trust, the programme put forward last year contemplated a capital expenditure of £3,000,000. If and when the construction of the new Docks in the Bombay Island Estates is undertaken this capital expenditure must increase. In view, however of the flourishing state of the finances of the Trust, there is no reason to doubt the ability of the Trust to meet the interest and Sinking Fund charges on any loan found necessary.

As already stated, the Development Loan placed on the market in the current year yielded the sum of 9 crores 389 lakhs. It is proposed to borrow a further sum of 5 crores in August of the current year. The distribution of this sum during the current and the coming years is as follows:—

	1920-21.	1921-22.
City Improvement Trust	275	225
Municipality	94.5	200
Port Trust	50	100
Government Schemes ..	420	130
	839.5	655

The above sketch is, however, extremely rough, and it may be necessary to expand the programme. For instance, owing to the shortage of funds in the Imperial Budget, the electrification of railways serving Bombay is hanging fire. It is possible that in view of the importance of speeding up communications between Bombay and its suburbs, Bombay may be asked to subscribe funds to allow of this being rapidly completed.

In conclusion, I have attempted to give a rough sketch of the steps now being taken to remodel what we are proud to think the second city in the Empire. I venture to hope that I have shown that in the changed conditions of modern Bombay, these schemes are justified and there is every prospect that they will be successful financially and will also tend to the improvement and beautification of the Island which all who live there love so well.

DISCUSSION.

The Chairman (Sir William Sheppard) said they had all listened with the greatest interest to the very lucid and informing paper which had just been read by Sir George Curtis, to whom their hearty thanks were due. What impressed one most about the scheme which the author had detailed was its boldness and importance, alike from the point of view of cost, of its effect on Bombay as one of the large entrepôts for India and the Far East and of its effect on Bombay itself as a residential area. With regard to cost, there were few works in India—indeed, none of the precise kind described—which had cost, or been expected to cost, so immense a sum as thirty millions. Even in Europe so large a scheme would be considered wonderful; he believed the renovation of Paris, to which Sir George had referred, only cost about half the proposed expenditure on Bombay. The magnitude of the work, however, had not deterred Sir George Lloyd and the Government of Bombay, and had clearly appealed strongly to the inhabitants of that city, as was evident from the alacrity with which they had passed the necessary legislation and subscribed to the Bombay Development Loan last year the sum of nearly ten millions. That seemed to him an extraordinary achievement, because improvement schemes as such, did not ordinarily appeal to those for whose benefit they were intended. India, during the time he was there, had been extremely conservative in matters affecting the daily life of the people, and nothing was less appreciated than an improvement which seemed likely to affect their personal habits and comfort. The attitude adopted towards schemes of improvement was rather one of "How will it affect me?", and during the whole life of the Improvement Trust there had been resentment against the demolition of buildings to which people were attached. That feeling had reacted in another direction and caused an outcry against what was alleged to be the unnecessary width of important streets, and even in the undeveloped land to the north of the Island the desirability of 100′ or 120′ main avenues of access from Salsette to the Fort had been questioned. Demolition of slum property had been the alternative proposition. That was a most laudable suggestion, but likely to be too expensive unless provision had previously been made in more open areas for suitable buildings of a thoroughly sanitary kind, access to which would only be possible

if the large main avenues were available and wide enough for all kinds of traffic. He presumed it might be assumed that that feeling of antagonism had died down, or was at any rate temporarily dormant, and it was to be hoped that a great portion of the new schemes might be carried through before it revived; that was particularly the case with regard to the Back Bay reclamation scheme. The Bombay Government were to be congratulated on the marked absence of opposition to their Back Bay scheme, because when he was in Bombay the words "Back Bay reclamation" represented something closely akin to the South Sea Bubble, and were anathema in many important quarters. The success of the comparatively small reclamation at the Colaba end of Bombay which was carried out in the early days of the Improvement Trust showed how great was the need for building sites in that direction, and he was glad to know that many more such sites would become available as the work progressed and that the public would obtain, in addition, valuable and beautiful parks and gardens. The provision of 50,000 tenements for the working classes was an important feature of the scheme. At the present time the workman or mill hand was becoming more articulate, and was ceasing to be satisfied with the conditions of life provided for him in the past. He had been living hitherto in overcrowded tenements known as chawls, where the only accommodation for himself, his family, and possibly lodgers as well, was one small room with perhaps a bit of verandah. The Europeans built their houses on the hills, but when life on hills began to appeal to their Indian brethren a gradual change took place, which was still continuing. Improvement was no new thing in Bombay, and there were many Governors and officials whose names were borne by prominent roads, bridges and buildings. Notable amongst those was Mr. Arthur Crawford, an early Municipal Commissioner, who anticipated by some years the need for roads in the northern part of the island, whose seven roads from Jacob's Circle were at the time denounced as extravagantly wide and were now found to be almost ridiculously narrow, whose name was perpetuated in Crawford Market, a building and market which for fifty years had served the needs of the south of the island, and who also built Elphinstone Circle—rumour had it in a single night. His wise but hasty expenditure was alternately denounced as mad extravagance and praised as an instance of wise provision. Among Governors he might mention Lord Sandhurst, who initiated the present Improvement Trust to remove the evils of overcrowding, which the plague in 1896 brought forcibly to notice. But improvement clearly began before the time of any of the persons he had mentioned, because, as Sir George Curtis had pointed out, Bombay when originally acquired by us, consisted of seven islands. The city had for its motto "*Urbs Prima in Indis*," and each successive census showed that the proud boast was fully justified. Bombay was the first city in India and the second largest in the Empire, a position sometimes unsuccessfully claimed by Glasgow. She would now become larger still and would he trusted, continue to be a shining example of good municipal government, of up-to-date facilities for trade and shipping, and of complete happiness of life.

Lord Lamington, G.C.M.G., G.C.I.E., having congratulated the Chairman on his appointment as a Knight Commander of the Indian Empire, said, he had always regarded Bombay as the most beautiful place he had ever seen, so far as outward appearance went. The view from the top of Malabar Hill of the city nestling in palm groves was wonderful. In his admirable paper, Sir George Curtis had shown how the city, beautiful to the outward eye, was going to be made more comfortable and healthy for the vast population that dwelt within its borders. Of the many important schemes which had been started or were about to be taken in hand, there was one which, when he was Governor of Bombay, had been very close to his heart, namely the reclamation of Back Bay. He had been told recently that the whole of the Bay was going to be reclaimed, and was very much relieved to learn that that was not the case. The reclamation of the whole of the Bay would have a disastrous effect on the health and comfort of the inhabitants; the wide stretch of water provided by the Bay did more than anything else to render bearable the great heat that prevailed in the hot season. He was glad to know that it was only the comparatively shallow portion which was being reclaimed to be used as a place where people might dwell, thereby augmenting the population and relieving congested districts. It had occurred to him when considering the project during his term of office that it might be a good thing to leave one or two small canals, which could be used by small boats. It seemed to him that Back Bay had never been properly utilised for small boats, and the making of a few small canals would be inexpensive. It would be pleasant to be able to go from Colaba to Malabar Point by water. That was, however, a very minor point. He hoped and believed that the reclamation scheme, now that it had been properly taken in hand, would be a triumphant success. As had been mentioned, as a corollary the Cotton Green was to be moved to the northern part of the island, thus improving the whole of the southern part of the city. Certainly another improvement would result from a removal of the unsavoury sewage works. Bombay would always hold a very dear place in his heart, and his only regret was that Lady Lamington was

not able to be present that afternoon. The call of Bombay to those who had known her was very strong; he noticed that Lord Reay, one of his predecessors in office, had, although he had been an invalid for some time, managed to be present to listen to the very interesting address which Sir George Curtis had given.

MR. J. P. ORR, C.B.E., C.S.I., Director of Housing, L.C.C., and formerly Chairman of the City Improvement Trust, Bombay, from 1909 to 1919, said that those who had been in Bombay during the last twelve years would know that the improvement schemes appealed to him very closely. It was with the greatest interest that he had heard of the progress which had been made in carrying into effect schemes which many of those connected with the city spent long hours in planning during those years of war when it was impossible to do anything towards carrying them out, because of the want of money and the absorption of everybody in more important affairs. That time had been utilised in preparing the schemes which were now being carried out, and it had been a great pleasure to him—and to many of his friends—to hear how the people of Bombay had risen to the occasion and had made up their minds to go in for big improvements which he was sure ten years ago they would have thought quite impossible. There was one small matter which he thought it might interest those present to hear about, and that was in connection with the main avenue. The construction of a main avenue through Bombay was very nearly rendered impossible. In the early years of his connection with Bombay it had been found necessary to adopt a new line for that avenue, because speculation had made the line originally chosen too expensive. With the greatest difficulty and with the utmost secrecy a new line was devised, and they were able to get the new scheme for the avenue, called the Sydenham Road, after Lord Sydenham, who had backed it from the first, through its crucial stages in the record time—for a Bombay scheme —of six months. It turned out afterwards that, had they delayed another fortnight in getting the scheme through, a certain site which had been applied for for a mosque would have been built on, and there would have been no place through which one could have got a 100′ road, because every avenue through the dense native quarter north of the Carnac Road was barred by mosques. The road was 100′ wide in the southern part, where land was too expensive for it to be wider, 120′ in the middle and 150′ in the north. They should all be very grateful to Sir George Curtis for having put the programme of improvement in Bombay before them in such a lucid manner, and he hoped Sir George—as well as he himself—would be able to go out to India and see the actual results of the new schemes in a few years' time.

MR. PURSHOTAMDAS THAKURDAS, C.I.E., thought it did not lie with him to say how very impressive Sir George Curtis's paper had been; he would rather leave that to the non-Bombay gentlemen who might follow him. As a native of Bombay, the pride of that city in the grandeur of the scheme which had been launched and in the promptitude with which the money has been raised was naturally to a great extent shared by him. Before dealing with the paper, however, he would like to express his satisfaction at the great interest which he had seen displayed that afternoon in the subject of the paper, a satisfaction which was increased by the fact that Lord Reay had made it convenient to be present and thus show that he had not forgotten Bombay in spite of the number of years that had passed since he was there. Personally, he made no claim to represent Bombay, but he was sure that when Lord Reay's friends in India learnt that his lordship had been present at the meeting that afternoon they would be very much gratified. He knew from experience how keen Sir George Curtis was on the schemes of improvement he had outlined. When the Bill was before the Council it was said that if Sir George Lloyd was the father of the scheme, Sir George Curtis was its godfather. If further proof of the author's enthusiasm was needed, it would be found in the fact that Sir George had only recently retired from Bombay after a period of exceptionally hard work, and one would have thought that on arriving in England he would have found it necessary and desirable to have a spell of rest, but instead of that, as soon as he saw a chance of informing people about what was being done in Bombay nothing could keep him from it. The Bill came before the Council of the Bombay Presidency at its concluding session in Poona last September, and it was considered desirable that it should be passed at that time, as otherwise it would have had to come before the new Council, which everyone thought would require some time for settling down. As Sir George Curtis would no doubt agree, the Select Committee appointed by the Council did their utmost to get the Bill through before the end of the session, and, although there was some trouble in making the different interests affected take a common point of view, Government did carry the Bill through the Council in all its stages without a dissentient voice. He had provided the only discordant note, when at the first reading of the Bill he objected to the cotton duty by which the whole scheme was to be financed. He was a cotton merchant, but that was not the point; he was not a cotton grower. He felt that the principle on which the scheme was financed was not one which could be allowed to pass without criticism. Cotton was being grown all over India, and came to Bombay simply because that city was a suitable port, and, if he might say so, on account of the enterprise of the Bombay cotton merchants,

which had made the Bombay cotton market the first in India. He felt that the incidence of the duty would fall on the grower, and to that extent he felt it necessary to draw the attention of his colleagues on the Council to what he had no hesitation in describing as the incorrect principle underlying the financing of the scheme. The present was the first occasion on which he had been outside India, and he could not help being struck by the useful work which had been done in this country, and could be done in India, by providing suitable methods of transport. That was particularly the case with regard to Bombay, where, as Sir George Curtis had said, in 1897 about two-thirds of the population were living in the southern quarter of the town. In England, people could live fifty or sixty miles away from their work and yet accomplish the journey in little more than an hour. He thought Sir George would agree that the whole question in Bombay was one of transit facilities, and that in spite of its being the second city of the Empire it was very backward in that respect. He could not help thinking that if some of the available energy and money was spent on providing fast transport for people who had to come to Bombay to work, the pinch, until the new schemes were completed, would be felt to a much smaller degree than would otherwise be the case. It was a difficult matter to ask people to vacate their houses before new ones were ready for them, but by providing good transport facilities so that they could live outside the city the problem might to some extent be met. The water supply of Bombay was very defective. London was well supplied with water on account of the proximity of the Thames, and Calcutta owing to the Hugli, but Bombay had no such supplies of fresh water as those. He wondered whether it might not be worth while for the Municipality to consider whether sea water could not be used for such purposes as flushing drains, watering roads, etc.

Mr. G. Owen W. Dunn, O.B.E., said he had listened to the paper with peculiar interest, because as Chairman of the City Improvement Trust from 1904 to 1909, he had been in close connection both with the Government and the Municipality. During those years the Trust had to pass through the inevitable period of lean times, when expenditure was large and the revenues had not had sufficient time to develop, the result being deficits in the annual accounts. He was glad to know that those times were done with and that the Trust at present showed a surplus of 33 lakhs. The point that struck him most in Sir George Curtis's very engrossing paper, was the changed attitude of both the Government and the Municipality towards the Improvement Trust. The latter body in the old days was left to fight its own battles to a very large extent; it met with constant opposition from the Municipality, and it was not too generously helped by the Government. He would like to give one or two examples of that. One of the means provided by the Improvement Trust Act for financing the Trust was by the vacant Government land in the island being made over to the Trust with a view to development, so that the revenue from that might be used to pay interest on the loans which had to be raised for other improvements in the city. When the Government, however, wanted a site for any purpose they simply took it away from the Trust. They had a right to do that under the Act, but they did it much too frequently. With regard to the attitude of the Municipality, on one occasion the Trust had to take over some slum properties with a view to demolition. For forty or fifty years the rain water from the roofs of those buildings had been allowed to run straight down on to the street without any protest being made, but as soon as they were acquired by the Trust a notice was received from the Municipal Engineer saying that rain-water gutters and down-water pipes must be fixed immediately. He was very glad to know that matters were now very different, and that the three great bodies were working together and taking a wider view. He was a little doubtful about the financial side of the scheme. When such a huge area of building land was placed on the market almost all at once the result might be a slump in land values which would upset all the financial calculations. He hoped that would not be the case. Bombay was exceedingly prosperous at the present time, as was the case during the American civil war, but after that war there followed a great period of depression, and such periods might come again, although he trusted that that would not be the case. He hoped the new schemes which had been taken in hand would make Bombay even more beautiful than at present, and be the great success Sir George Curtis thought they would be. He would like to express the great pleasure which all those who knew the Chairman felt that he had at last received the honour which had been due to him for so long. All those who had served with the Chairman would agree with Lord Lamington that the honour which had been bestowed on him was thoroughly well earned.

Sir Thomas Bennett, C.I.E., M.P., in proposing a vote of thanks to Sir George Curtis for his admirable paper, said the author had given what he might call a Bombay *tamasha*—for with a subject such as he has shown, one might always count upon securing a large assembly of Bombay people. There seemed to be a real Bombay spirit, a sort of local patriotism which it was well worth while keeping alive. He thought the paper gave an answer to the question on which Mr. Montagu spoke very warily the other day, when he was asked whether the new census returns would settle once and for all which was the real *urbs prima in Indis*. Mr. Montagu was cautious, having

Calcutta in mind; but those who were or had been connected with Bombay "did not care tuppence for Calcutta;" they had the census in their favour and they had the huge new projects which had been described that afternoon to strengthen their belief in the primacy of Bombay. He believed those projects would be a great success. One speaker had seemed a little pessimistic, but personally he thought the right philosophy in such a matter was that of the cavalry drill sergeant, who said to his pupils "Throw your heart over, and the horse will follow." The Governor of Bombay—as energetic a Governor as they had ever had—had thrown his heart over, and they might be sure the horse would follow. Let them go on with their big avenues, and build the city worthily. The paper had given all those who had been connected with Bombay a new affection for the old city and a greater faith in its future, and he asked the meeting to accord to its author a very hearty vote of thanks.

SIR HENRY LEDGARD, in seconding the motion, said he had been greatly interested in the paper, especially as for the last five or six years he had been keenly interested in a similar development scheme, which, while not so large as that proposed for the first city in India, nevertheless involved taking in twelve square miles of additional area and was important in its way. In consequence of the interest he took in that scheme he had listened to the paper with special pleasure.

The motion was carried unanimously.

SIR GEORGE CURTIS, in reply, thanked the various speakers for their appreciative remarks. Dealing with Mr. Purshotamdas's suggestion with regard to the use of sea-water for certain purposes, he thought such a scheme would not pay, as it would involve laying separate mains. A scheme was under contemplation, however, for increasing the water supply by 50 million gallons. In reply to Mr. Owen Dunn, it was true that the future lay on the knees of the gods, and until the land was actually put on the market one could not say with certainty what it would fetch; but from recent experience there was no reason to believe that the anticipations of the authorities would not be fulfilled, and in any case a large profit was assured.

The meeting then terminated.

MR. N. N. WADIA, C.I.E., writes:—

Owing to the lateness of the evening, I was unable to make a few remarks which I intended to do, on the very interesting paper read by Sir George Curtis, on "The Development of Bombay." At the outset I must congratulate Sir George Curtis on the able manner in which he worked out all the details of the scheme which his Excellency Sir George Lloyd, taking a large view of the future of Bombay, was able to inaugurate.

The few questions I should have asked Sir George Curtis are as follows:—

1. Does he think that acquiring, under the Land Acquisition Act, ground for the Worli Scheme by the Improvement Trust at Rs. 7 and Rs. 8 per square yard and then selling it again in a year or so, after development, at Rs. 50, which he estimates it would fetch, a fair proposition? In my opinion, the Land Acquisition Act was never intended for such purposes and it is causing a lot of discontent amongst the holders of land as they are forcibly made to part with it at the low figure.

2. Will not keeping the price of the resale of such land at Rs. 50 hinder rapid housing under this scheme, as the high price of ground and the high cost of building materials at present in Bombay will necessitate landlords charging a high rent for such houses erected?

3. What is the necessity of making a wholesale acquisition of ground by the Government of Bombay in the Salsette Peninsula, which they are doing, at about 4 annas per square yard, and then intending to sell later on at about Rs. 4 or Rs. 5 per square yard?

4. Will not such acquisition and such a resale of ground at high rates give a handle to the Extremists for agitation against Government, and also turn some moderate business men against the Government owing to this unfair treatment?

5. Regarding the Back Bay Reclamation Scheme, is it true that the Government of India have agreed with the Government of Bombay to take over about 120 acres of reclamation ground for military purposes at about Rs. 12 per square yard, *i.e.*, at the actual cost of reclamation and further on condition that the Government of India claim from the Bombay Government the major portion of the value they will receive for the ground of the Marine Lines which will be vacated by the military and sold by the Government of Bombay for offices and housing purposes? Why should the Government of Bombay agree to give the ground to the Government of India at cost rate when they are going to sell the ground to the public for housing at Colaba for at least Rs.50 per square yard, and why should the Government of India make a huge profit on such vacated land?

6. What is the idea of appointing an Advisory Committee at such a late date, say eighteen months after the Development Board was formed, when all the schemes for reclamation and development have been settled, contracts given out and the schemes are in progress? Is this Committee supposed to be a guide to the Board in an Advisory capacity or merely an Information Bureau to give information to the public?

7. I congratulate the Bombay Government on the great success of the loan of 9 Crores,

which they raised at 6½% interest, free of income tax, last year, on the guarantee of the Bombay Government only. This loan compares very favourably with the sterling loan lately floated in London by the Government of India at 7%. Is the credit of the Government of India so low in London that they are forced to pay 7% when cities like Birmingham, Glasgow and Reading and even the Ceylon Government, can raise loans at about 6% in the London Market?

These questions I would like answered and carefully considered in London, as they are likely to cause great friction and agitation in India, for which we are giving illegitimate grounds in my opinion. and it is with this in view, that I venture to write this letter so that such causes may be removed.

I did, at an interview with his Excellency Sir George Lloyd, last year, place before him a scheme by which the original owners of land could be allowed to acquire the ground taken from them under the Acquisition Act, by paying the average cost of improvement for the locality and a reasonable profit to the Improvement Trust. Would Sir George Curtis say whether such a scheme, in his opinion, would be able to lessen all this agitation which is now taking place in Bombay?

The schemes, as planned by the Government of Bombay, are far-reaching, and I hope in due time they will fulfil all the expectations of the Government of Bombay by the sale of all such developed land at reasonable prices and the provision of houses for all classes of people, built at reasonable rates so that they can be let at reasonable rentals.

Sir George Buchanan, K.C.I.E., M.Inst.C.E., in a written communication says he regrets very much that a pressing engagement prevented him attending the meeting, and he, therefore, forwards the following few details which he thinks may be of interest respecting the method of carrying out the Bombay Back Bay Reclamation Scheme.

He thinks that it is not sufficiently realised by those who only see Bombay in the cold weather, that for some four and a half months in the year, namely, from the end of May to the middle of October, Back Bay is exposed to the whole force of the South-West monsoon, and to protect the reclaimed area from the action of the sea, a particularly strong sea wall is required. The length of the wall will be almost exactly four miles and it will be formed of a rubble mound of large stones protected on the sea side by blocks weighing from five to ten tons each, and surmounted by a solid concrete superstructure.

For the rubble mound over one million tons of stone will be required, and this is to be obtained from quarries now being opened up at Kandivlee, 15 miles from Bombay on the Bombay, Baroda and Central India Railway.

The making of this quarry is in itself an engineering work of some magnitude, and an output is aimed at amounting to over 1,000 tons per diem. The very latest quarry machinery and applicances will be employed, and it is safe to say that no such quarry has previously been made in India.

The stone will be conveyed from the quarry by trains of specially constructed wagons, and on arrival at Bombay the wagons will be taken along a temporary timber gantry extending for the whole length of the wall and tipped direct on the site.

The four miles in length of reclamation will be divided into sections by the construction of cross walls from the sea wall to the existing land line, and as each section is finished the work of reclamation will be taken in hand. The total amount of filling required is 27 million cubic yards, or to put it another way, the equivalent of a space five miles long, one thousand yards broad and nine feet high. An attempt to bring this vast amount in by trains or carts as in the case of small reclamations would be obviously very costly, and take an immense time. It has, therefore, been decided to obtain the material by dredging in the harbour on the east side of the Colaba peninsula and pumping the material through pipe lines across the peninsula into the Bay. The dredger is to be capable of dredging at the depth of 70 feet, 2,000 cubic yards of solid material per hour, and discharging the same through a pipe line 5,000 feet long, but as the total length of the pipe line required amounts to over 12,000 feet, it will be necessary to have a subsidiary pumping station at the end of the first 5,000 feet.

The whole work is to be carried out departmentally, as, owing to the great fluctuations in the price of machinery, materials and labour, it was impossible to let a contract on satisfactory conditions, and although this arrangement involves a great deal more work for the Resident Engineer and his staff, it will probably in the long run be more economical.

CORRESPONDENCE.

"PHONOSCRIPT."

May I be permitted briefly to traverse Miss Deane Butcher's note of July 1st, referring to my paper? Miss Butcher's Orthotype employs detached diacritics. I did not assert that these diacritics were similar to those of dictionaries. Dictionaries use the common accent marks. Orthotype employs instead, small detached shorthand characters. Both require separate writing; both alter the proportions of the visual impression of the vowels. Miss Butcher points out one important difference. She says her shorthand characters "do not *distinguish* the vowel letters, but, on the con-

trary, *extinguish* them." That is true, and is, in my judgment, a very grave fault in her scheme. In her instructions to teachers she advises them to "*cover over the vowels* and let the pupils read the words from the shorthand signs." This obliteration of the actual word-form is the very opposite of the aim of "Phonoscript," which is to give every letter a constant value without destroying either the proportions of the letters or the visual impression of the word as a whole. This being so, I do not understand why she accused me, in the discussion following the reading of my Paper, of having "infringed her patent."

I greatly admire Miss Butcher's original and ingenious contribution to the problem of teaching English pronunciation to foreigners, and her resourceful energy in supporting it, but if I had thought it adequate I should not have attempted my own.

A. E. Hayes.

NOTES ON BOOKS.

The Foundations of Chemical Theory. An Introductory Text-Book. By R. M. Caven. London: Blackie and Son, Ltd. 12s. 6d. net.

The author's expression "Foundations of Chemical Theory" must be regarded rather as a simile, a metaphor, than literal or exact; hence some doubt as to its manner or use. We are inclined to think, however, that Dr. Caven's main "Foundations," as he wishes his readers to understand the term, are such carefully conducted or conclusive experimental researches or studies as Bacon terms crucial instances, although sometimes his order or sequence of treatment would suggest a reverse sense in which a mental inspiration is the foundation and experiment or observation a confirmative superstructure.

Thus in the chapter on "Equivalent Atomic and Molecular Weights," Dr. Caven figures and explains (p. 22) a sequence of four electrolytic cells in which hydrogen, copper, silver, and gold are liberated by an electric current passing through all four cells, the ratio weights liberated being marked along-side the cells. In a similar way, other crucial instances in experimental work are illustrated or explained in close juxtaposition with the theories or views which they support so that in the work under notice, we have an admirable summary of the usual or current chemical hypotheses with a study of the leading facts upon which the modern views are based.

Dr. Caven's book is well adapted for the purpose indicated in the preface: something for the chemical student to read at the end of his second year's course, "for the purpose of knitting together his chemical knowledge in view of the more advanced studies which lie before him."

The subject matter is presented in a form adapted to the usual teaching routine of the present day, and allowing for the chemical progress of nearly 60 years, Dr. Caven's book may be regarded as a near equivalent of Galloway's second step in chemistry, which was published in 1864. To say this is perhaps the highest praise, when one remembers the influence which Mr. Galloway's book had on the teaching of chemistry: it is interesting, however, to notice how much of the actual subject matter has come into being since the issue of Galloway's second step.

In the chapter on the classification of the elements, Dr. Caven gives a thoughtful and suggestive exposition of the periodic law in various aspects and teachings: while the chapters on the states of matter, liquids, solids, solutions and dilute solutions, afford a sequent and ordered study of present-day views as to chemical statics and chemical strains or tensions. The colloidal state is briefly considered, but fully as regards essentials for students of the grade for which the book is intended. After an approximate study of the degree of porosity of various filled or prepared papers, we have a graded tabulation of exemplar colloids: one extreme (colloidal platinum) bordering on the suspension of a non-colloid, and the other extreme (dextrine) bordering on a true solution.

The chapter on Equation Building, embodies eminently practical and useful suggestions for aiding the student in finding a way through the intricacies which sometimes present themselves, but to prevent students gathering false notions as to the nature and functions of chemical equations, Dr. Caven introduces the subject with a page or so of useful cautions: cautions well worth consideration and remembrance by every student of chemistry. The chemical equation in itself proves nothing, but may illustrate or concisely represent a fact. A chemical equation does not explain a chemical reaction; it expresses it, with certain limitations. In a cautionary tone Dr. Caven touches on the danger of magnifying the equation unduly and regarding it as a kind of talisman by means of which natural processes may be foretold or brought to pass. Beginners, he tells us—in faithfulness to the principle of the indestructibility of matter—suppose that the exigencies of chemical science are completely satisfied if nothing is lost by the way.

A hint, like the above, that matter may not be a self-existent reality, but perhaps something contingent, subjective, or even dimensional in time, is by no means out of place. Modern investigators, like Dr. Caven's beginner, are apt to depend a little too much on the necessarily imperfect conclusions deduced from laboratory work and to neglect the various hypotheses and speculations as to matter some of which are several thousand years old.

Coke-Oven and By-Products Works Chemistry. By Thos. Biddulph-Smith. London: Chas. Griffin & Co. 1921. 21s.

The author is Chief Chemist in the Coke-oven and By-products Works, at Stocksbridge; hence perhaps the somewhat complex title—a title not easy to construe without this knowledge.

In the book itself, we have a good practical treatise on the Chemistry of the Coke-oven, and this volume of 180 + X pages with folding plates should prove a servicable companion to anyone who has charge of coke-ovens.

Technical details are given with notable thoroughness and exactness: a good feature of the work being that when the author does not know, he in no sense conceals the fact. Thus, for example, when touching on the estimation of ammonia in the hot moist gas, he says that he is unable to give a method which can be relied on, but he gives the best method known, states faults and makes suggestions.

First in order, the sampling of coal and coke is treated of, then follows instruction for the analysis, special consideration being given to sulphur, phosphorus and nitrogen, as involving more difficulty than is incident to the determination of the main constituents.. This chapter includes a test as to coking properly, a flotative method for separating free coal in shale and a formula for a first estimate of calorific value as deduced from the analysis.

Next the gaseous products are considered, followed by particulars as to distillation plant and the testing of tar products; after which the production and testing of ammonium sulphate is dealt with.

Chapter VIII, which treats of practical calorimetry and also pyrometry, is of rather special interest; a prominent place being given to Mr. Darling's fuel calorimeter which with proper care, gives quite satisfactory results, with the advantage of that full visibility of the operation at all stages, which is not realised when the ordinary "bomb" form is used.

The chapters on the separation of benzene and volatile distillates are characterised by thoroughness, comprehensive graphs affording data for guidance.

In an appendix, an account, in condensed paragraphs, is given of the leading coal tar products; after which various tabular matter is given.

Practical Leather Chemistry: A Handbook of Laboratory Notes and Methods for the Use of Students and Works' Chemists. By Arthur Harvey. London: Crosby, Lockwood and Co. 1921. 15s. net.

We cannot regard the present work as a treatise on Leather Chemistry in a full or ordinary sense of the term, it being mainly a sequence of instructions as to testing or analysis of materials used in the manufacture or treatment of leather, with a short chapter on the analysis of leather itself.

An interesting feature is blank pages between the chapters; possibly an advantage as against the usual marginal notes and inset slips, as used by the ordinary worker, the weak side of blanks left by the printer being that they do not always come in the right place.

The analytical details are quite useful, and well selected; moreover, there is serviceable tabular matter in the appendix, but here, again, the sentiment of blank paper asserts itself, as the tabular matter on the opposite pages 198 and 199 could have been easily put on one of the pages, and a similar remark applies to the matter on the opposite pages 200 and 201.

To summarise, Mr. Harvey's book is a useful guide to the chemical examination of leather and of materials used in the leather industry.

Economic Mineralogy: A Practical Guide to the Study of Useful Minerals. By Thomas Crook. London: Longmans, Green and Co. 25s. net.

This book has been written with the object of meeting the needs of those who are concerned with the utilitarian side of mineralogy. For these a fairly complete study of the scientific aspects of the subject is necessary, although certain aspects, *e.g.*, the crystallographic, which are treated in detail in books on pure mineralogy, can be discussed quite simply from the economic point of view. In this volume crystal symmetry is dealt with only as an introduction to crystal optics. Chapter IV. is devoted to the latter subject, which is treated in some detail as crystal optics and the use of the polarising microscope are of great value to the practical student, and often assist in quick identification in cases where other tests cannot be so readily applied.

In the classification of minerals three principal methods may be adopted—the chemical, the genetic, and the economic. Mr. Crook adopts the last, in which the minerals are grouped as far as possible according to their uses. He divides them under three main headings: (1) ore minerals; (2) gem minerals; and (3) miscellaneous economic minerals, and the minerals are arranged in alphabetical order under these headings. Exception may be taken to this method of classification by some on the ground that the basis is not scientific, but for practical purposes it has great advantages in facilitating reference. The names of the minerals are printed in heavy type, and it is very easy to turn up the section to which one wishes to refer.

The determinative tables at the end of the book are very useful. A list of minerals is given, and after each name we find particulars of its hardness, specific gravity, fusibility, streak, and in the last column its other most marked characteristics. The index appears to be very full and carefully compiled.

Animal and Vegetable Fixed Oils, Fats, Butters, and Waxes: Their Preparation and Properties. By C. R. Alder Wright. Third Edition revised and enlarged by C. Ainsworth Mitchell. London: Chas. Griffin & Co. 1921. £2 16s.

When the laboratory worker takes this somewhat ponderous volume (XIV. + 940 p. and plates) in hand, he will realise with satisfaction that it is so flexible as regards the binding as to remain open on the bench without being weighted down by the nearest heavy article, and on turning over the leaves, he will soon notice the complete absence of such waste matter as is often termed padding. Further acquaintance with the work will confirm the first favourable impression, and by reason of its fulness, conciseness of diction, abundant references, and thoroughness, the laboratory worker may find that it can stand him in better stead than other works in several volumes.

The oil and fat industry—perhaps now the most complex and differentiated of all our leading industries—was quite primitive in its methods before Scheele, the Swedish Apothecary, to whom science and industry owe so much, prepared glycerine from lard (1779). Chevreul followed by showing the true relation of glycerine to the fatty acids, but it was about the time of the 1851 exhibition that the new fat industry drifted towards shape. Glycerine was then a somewhat rare pharmaceutical product, and we find record of an exhibition medal to Davy, Mack-Murdo & Co., for pharmaceutical products, including glycerine.

At this time, however, the labours of Wilson and his associates (Price's Patent Candle Company) were culminating, and highly purified glycerine, together with fatty acids—chiefly in the form of candles—became commercial and industrial realities. It is interesting to note, in passing, that the war has led to new aspects: glycerine by the fermentation of sugar, and the glycols *in posse* as substitutes for glycerine. Almost the whole of the volume before us deals with matter of the period after 1851.

The first typical classification of Fixed Oils in our Wright-Mitchell volume terminates with a note on the recent and unexpected discovery of hydrocarbon oils in certain fish oils, and in one case the hydrocarbon oil formed the main constituent of a shark liver oil: the hydrocarbon being an unsaturated hydrocarbon of rather notable interest. It has the formula $C30\ H50$, yields a do-deca bromide, and hardens on exposure to air by oxidation.

In the May, 1921, issue of the *Journal of the Chemical Society* will be found (p. i. 297) a note having an interesting collateral bearing on the above: Mr. Kobayashi finds that herring oil readily yields hydrocarbons by decomposition, and this investigator attributes the formation of Japanese petroleum to the decomposition of marine animals.

The cataloguing of the saturated fatty acids and the very thorough study of the unsaturated fatty acids has a cardinal bearing on the modern method of treating and hardening by hydrogenation; a method treated very fully, both from the theoretical and practical aspects.

Extraction is discussed in light touches as regards the more ancient practice of rendering, boiling in water, and moderate pressure, but very fully as regards modern appliances, high pressure and the economic use of solvents.

Testing oils and fats and purification are fully considered, and this, in relation to uses and commercial exigencies, while soap, candles, the so-called "margarine," lubrication, and glycerine are similarly considered with a useful blending of theory and practice.

A quite exceptionally good index crowns the work, and the impression is so clear and so uniform in blackness, that it is fair to mention Messrs. Bell and Bain, of Glasgow, as the printers.

GENERAL NOTES

Coal Transport.—The cost of transport of coal from the mine to the destination represents so large a proportion of the total cost to the consumer, says *The Engineer*, that many suggestions have been put forward for eliminating the necessity for transport altogether. At the recent annual meeting of the American Society of Engineers in New York, a proposal was made and discussed for bringing coal to that city from the anthracite regions of Pennsylvania, by forcing it through two 14in. pipes by water pressure. There is a fall of some 2,000 feet between Scranton, which is 130 miles distant, and New York, and therefore coal and water in the proportion of 50 per cent. each would, it is estimated, travel at the rate of 7 feet per second. The two pipes would convey 7,000,000 tons of coal per annum to the City, and this quantity would meet the requirements of the population of 5,500,000, and leave a surplus for the supply of other communities on the route.

Production of Castor Beans in Java.—Castor bean production is now encouraged in Java, according to a report published by the U.S. Bureau of Foreign and Domestic Commerce, the oil being already used by the natives, especially for the Battik textile industry. It has been found that the seed can be safely grown under copra trees, the yield per acre adding considerably to the native's profit on the copra. During the first half of 1920 exports of castor beans from Java amounted to 742,000 kilos (kilo equals 2.2 pounds), against 301,000 kilos for the corresponding period of 1919 and only 99,000 kilos during the first six months of 1918.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2)

NOTICES.

DOMINIONS AND COLONIES SECTION.

At their last meeting, the Council decided that in future the Colonial Section of the Society shall be known as the "Dominions and Colonies Section."

EXTRA MEETING.

THURSDAY, JULY 14TH, 1921: MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair. A paper on "Paints, Painting and Painters, with reference to Technical Problems and Public Interests," was read by Professor H. E. Armstrong, Ph.D., LL.D., F.R.S., and Mr. A. C. Klein.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURE.

MICRO-ORGANISMS AND SOME OF THEIR INDUSTRIAL USES.

By A. CHASTON CHAPMAN, F.I.C., F.R.S.

LECTURE I.—*Delivered November 29th*, 1920.

When recently I was honoured by being asked to deliver a course of Cantor Lectures it was suggested that a discussion of some of the phenomena of "fermentation," using that word in its older and wider sense, would probably be of general interest and might be acceptable to the Fellows of the Society. After a little consideration I decided to deal with the subject on a very broad basis and to devote myself to a discussion—necessarily very brief and imperfect—of some aspects of industrial micro-biology regarded as a special branch or department of chemical industry. The inducement to deal with the subject in this general manner was the greater, since fermentation in its more modern and restricted sense—that is alcoholic fermentation—has already been somewhat fully discussed in its various aspects by previous Cantor Lecturers. Since 1878, when the earliest course of Lectures on Brewing was delivered by my old teacher and friend, Charles Graham—to whose memory I desire, in passing, to pay a tribute of affection and respect—the subject has been most ably expounded by such authorities as Hartley, Gordon Salamon, Percy Frankland, W. J. Pope and Adrian Brown. To the earlier chapters of the fascinating story of that most wonderful organism, yeast, and its relation to the production of alcohol, I do not propose to refer, as the subject matter is probably well known to all who are present here to-night.

I propose to commence with the capital discovery by Büchner in 1897, that fermentation, like many other changes effected through the agency of the living cell, is due to an enzyme, to which he gave the name zymase. I cannot, however, refrain from reminding you as a remarkable instance of scientific acumen, and as shewing the tendency to-day to revert to some of the older and discarded theories of physical science, that Liebig towards the end of his life in his memorable controversy with Pasteur, contended that the actual agent in the production of alcohol and carbon dioxide from sugar was not the living protoplasm of the yeast cell, regarded as a physiological entity, but some active nitrogenous substance produced by it. Although Büchner's discovery did not really diminish but rather added to the complexity of the phenomena in question, and did not facili-

tate in any way the commercial production of alcohol, it had the very great advantage of bringing one more process within the region of ascertained or ascertainable chemical laws, and of giving a very great stimulus to the further study of the mechanism of a process, which had, up to that time, been regarded as a conspicuous example of the direct operation of some mysterious vital force.

Following quickly on the recognition of the enzymic nature of alcoholic fermentation, came the work of Harden and his colleagues which did much to elucidate the subject. In the first place it was shown that when the expressed yeast juice, which contains the active exciting-principle, was filtered through a Chamberland filter, impregnated with gelatine, neither the residue remaining on the filter, nor the filtrate itself, was capable of bringing about the fermentation of sugar. When, however, the two portions, that is the residue on the filter and the filtrate were reunited, their activity was restored. In this way it was recognised that alcoholic fermentation requires the presence of at least two active agents, the enzyme, zymase, and a substance of unknown character, which is filterable through gelatine, and which has been designated the co-enzyme. The activity of zymase is destroyed by heat, whilst that of the co-enzyme remains even after the solution containing it has been heated to the boiling point. In the course of his work Harden observed that the addition of sodium or potassium phosphate to sugar solutions which were undergoing fermentation, was followed by a rapid increase in the evolution of carbon-dioxide. This observation was the starting point of an investigation which has thrown valuable light on the mechanism of the fermentation processes. It was found that there was a definite relationship between the amount of phosphate added and the volume of carbon-dioxide liberated, a molecular proportion of the phosphate always resulting in the disengagement of a molecular proportion of carbon-dioxide. An attempt to ascertain precisely what happened to the added phosphate resulted in the discovery of a new compound, consisting of a hexose sugar residue and phosphoric acid which has been designated hexose phosphate, and to which the formula $C_6H_{10}O_4\ (H_2PO_4)_2$ has been assigned. When the phosphate is added to a fermentable solution in the presence of zymase and the co-enzyme, it is supposed that one molecule of sugar (dextrose) breaks down into alcohol and carbon-dioxide, whilst a second molecule reacts with the phosphate to form the hexose phosphate, the two reactions proceeding in accordance with the following combined equation:

$$2C_6H_{12}O_6 + 2Na_2HPO_4 \\ = 2CO_2 + 2C_2H_6O + 2H_2O + \\ C_6H_{10}O_4\ (Na_2PO_4)_2.$$

In practice it is well-known that worts containing only a limited amount of phosphate, but relatively very large proportions of fermentable sugar, are capable of undergoing complete fermentation, and it is clear that according to the above view, this could not happen unless the phosphate were in some way or other regenerated. Harden considers that the yeast cell contains an enzyme to which he has given the name "hexosephosphatase," the function of which is to effect the hydrolysis of the hexosephosphate in the following manner:

$$C_6H_{10}O_4\ (Na_2PO_4)_2 + 2H_2O = \\ C_6H_{12}O_6 + 2Na_2HPO_4.$$

Summarising the above statements the following may be regarded as the general nature of the fermentation process.

The enzyme zymase and its co-enzyme together act on the sugar (hexose) in the presence of the phosphate, in such a way that one half of the sugar is decomposed into alcohol and carbon-dioxide, whilst the other half unites with the phosphate to form the hexosephosphate above referred to. The phosphate is thus rendered temporarily inoperative, but is liberated by the action of the enzyme "hexosephosphatase," which reproduces the sugar and phosphate, and so the cycle of change is ready to be repeated.

It will be seen that the above theory does not purport to tell us by what stages, if any, the dextrose molecule breaks down, but merely deals with the alcohol and carbon-dioxide which are under ordinary circumstances the final products of its disruption. At one time it was widely held that lactic acid was formed as an intermediate substance, but for various good reasons that view has now been abandoned. Some years ago it was suggested by Fernbach that pyruvic acid is an intermediate product in the breaking down of the sugar molecule, and a good deal of evidence in support of that view was brought forward. Pyruvic acid appears to be readily

fermentable by yeast with the production of acetaldehyde and carbon-dioxide, and it is supposed that the aldehyde is then reduced to alcohol by hydrogen formed in another stage of the process. In confirmation of the substantial correctness of this explanation two important observations may be mentioned. In the first place it has been shown by Harden that in addition to phosphates, potassium pyruvate and acetaldehyde are both effective in restoring the activity of yeast preparations from which the "co-enzyme" has been washed out, and more recently Neuberg and his colleagues have found that if the fermentation of sugar be carried out in the presence of sodium sulphite, there is an actual accumulation of the acetaldehyde-bisulphite compound, and that under certain conditions as much as 73 per cent. of the theoretical quantity could be obtained.

They have shewn that when the fermentation is conducted in the presence of considerable quantities of sulphite the formation of one molecule of aldehyde is accompanied by the production of one molecule of glycerine, from which it follows that the actual weight of the latter compound produced under these conditions is approximately twice that of the former. This is shewn by the following results:—

Sulphite present.	*Aldehyde produced.*	*Glycerine produced.*
grammes.	*grammes.*	*grammes.*
33	11.9	23.37
50	12.52	24.86
75	13.89	27.61
150	18.65	36.90

From this it would appear that the equation representing alcoholic fermentation in the presence of sulphite, may be written in the following form:—

$$C_6H_{12}O_6 = \underset{\text{Acetaldehyde}}{CH_3COH} + CO_2 + \underset{\text{Glycerine}}{C_3H_8O_3}$$

Inasmuch, moreover, as there is evidence that the sulphite takes an actual part in the process, the equation may be expanded in the following manner:—

$$C_6H_{12}O_6 + Na_2SO_3 + H_2O =$$
$$\underset{\text{Glycerine}}{C_3H_8O_3} + \underset{\text{Sulphite compound of acetaldehyde}}{CH_3.\ CH(OH).\ O.\ SO_2Na} + NaHCO_3$$

It will be noticed that in this reaction sodium bicarbonate is formed, which probably brings about the decomposition of the aldehyde compound, with the production of free aldehyde which is then transformed, by the reducing action of the yeast, into alcohol. Having regard to these well-established facts, there would appear to be very little doubt that pyruvic acid and acetaldehyde are, in fact, intermediate compounds formed in the mormal process of alcoholic fermentation.

More recently, it has been shown by Neuberg and Ehrlich that the commencement of fermentation is considerably accelerated by aldehydes generally, the acceleration at constant temperatures being, in some cases, more than one hundredfold.

The interesting observation has been made that fermentation by yeast-juice is accelerated to a greater extent than fermentation brought about by the living cell, the explanation being apparently that, in the latter case, aldehydes are probably produced by intra-cellular decomposition of the amino-acids.

It is remarkable that the aldehydes, which have always been regarded as toxic to living cells and inhibitory of enzymic activity, should prove to be such powerful stimulants of alcoholic fermentation.

As if this picture, which affords in all probability only an incomplete idea of the great complexity of the process, were not sufficient to excite our admiration of the wonderful chemistry of the living cell, there is the further fact that the behaviour of the enzymes within the cell differs materially from that of the same enzymes in the expressed juice. Thus, in the case of the juice, the velocity of fermentation is apparently dependent on the rate at which the emzyme hexosephosphatase decomposes the hexosephosphate, freeing the phosphate for further action. In the living cell, however, the velocity of fermentation is much greater, and it would appear that in its natural surroundings within the cell, the enzyme is free to act without the disturbing influences which probably exist in the expressed juice, where all the cell contents are mingled and some substances may well interfere with the activity of others. As in all cases where living organisms are concerned, the process is one of extreme complexity and compared with the apparent ease with which all these wonderful changes are accomplished by the yeast cell, the greatest triumphs of the modern organic chemist pale into insignificance. I have often quoted, and would like once again to quote from the late Professor Meldola

who says in his introduction to "The Chemical Synthesis of Vital Products": "When we can transform sugar into alcohol "in the laboratory at ordinary tempera-"tures by the action of a synthesised "nitrogenous organic compound; when we "can convert glucose into citric acid in "the same way that *Citromyces* can effect "this transformation; when we can build "up heptane, or cymene, or styrene, or "when we can produce the naphthalene or "anthracene complex in the laboratory by "the interaction of organic compounds at "ordinary temperatures, then may the "chemist proclaim with confidence that "there is no longer any mystery in vital "chemistry."

And again

"The ordinary chemical equation repre-"senting the genetic relationship of one "vital compound to another is apt to delude "those who are not experts in chemistry "into the belief that it is all-sufficient and "that it 'explains' the biochemical process: "as a matter of fact *the sign connecting the* "*two sides of the equation stands for the* "*whole unexplored region of biochemical* "*transmutation.*"

This is in fact the key note of these lectures, for I firmly believe that as chemists we shall—for a long time at least—become more and not less, dependent on the powers (both synthetical and analytical) of living cells, and that it behoves us to study carefully the conditions which affect the activities of those cells, and which may even induce them to function in one direction or another at will.

It is quite unnecessary for me to point out how much modern industrial chemistry, both on the inorganic and on the organic side, owes to the intensive study, during comparatively recent years of the phenomena of catalysis. In the living cell we have the manufactory and the temporary storehouse of nature's own catalysts, and with the extended and more concentrated study of these, we may hope to see the realisation on a large scale of many reactions which are at present of merely laboratory interest.

Although an enormous amount of work has during recent years been devoted to the study of enzyme action, it is unfortunately true that we are at the present time very much in the dark as to its precise nature. It is becoming clear that in many cases at least, the colloidal substance which was for long regarded as the actual enzyme, needs the presence of some other substance in order that it may manifest its activities. I have already referred to the part played by the so-called co-enzyme in alcoholic fermentation and many other similar instances are known. Thus the enzyme Laccase is known to be inactive in the absence of traces of manganese. Traces of calcium salts are apparently necessary for the action of pectase on pectin and diastase is rendered more active by the addition of a small amount of asparagine. How far the different properties of the enzymes to which I have referred are due to differences in the quantities or nature of these so-called "accelerators" or "activators" it is, of course, impossible to say, but it may well be that the detailed study of these important accessory substances will greatly facilitate and extend the application of enzymes to industrial catalysis.

Reverting for a moment to the fermentation of sugar by yeast juice it is important to note that in several other respects than in velocity, the reactions which proceed in the juice differ from those occurring within the cell, and it seems not improbable that the mechanism of fermentation is in some way connected with some organized structure of the cell. Experiments which have been made on the distribution of phosphorus appear to suggest that the nucleus itself may prove to be in some way directly concerned in the fermentation change. In the light of the cytological researches of Wager and Peniston, Guilliermond, Fuhrmann, Henneberg and others it is not perhaps going too far to suppose that the cell may have a well-defined internal anatomy and that there is localisation of the various enzymes, and consequently of the different functions of the cell. It is possible that the microscopical study of the unstained cell by means of ultra-violet light as worked out by Barnard may be helpful in giving us a better insight into its internal structure. However this may be, it is very certain that one and the same organism may be made to perform different functions according to the conditions under which it is compelled to carry out its activities. An example of this is seen in connection with the decomposition of certain carbohydrates (dextrose and mannitol) by the well-known bacterium *B. coli communis*. E. C. Grey, whose work on the subject is of great interest and importance, shewed that the fermentation

change in question is brought about by definite enzymes acting always in the same manner. In his earlier experiments it was shewn that by one reaction alcohol, acetic acid and succinic acid were formed, and that by another lactic acid was the chief if not the sole product. Quite recently, however, he has succeeded in proving that by carrying out the fermentation in the presence of calcium formate it is possible to upset the balance existing between certain of the products, and so to shew that these products are in reality formed by separate enzymes. The formation of lactic acid appears to be produced by a mechanism which is independent of that giving rise to the other products, and so it has been established that under the influence of the enzymes present in *B. coli communis* three distinct groups of products may result. They are

(1) Formic acid, carbon-dioxide and hydrogen.

(2) Alcohol, acetic acid and succinic acid.

(3) Lactic Acid.

It would seem that these three groups of compounds represent three distinct and fundamental lines of cleavage of the sugar molecule. Incidentally, attention may be called to the fact that Grey has succeeded in proving (I believe for the first time) that the nascent hydrogen produced during the fermentation process is actually concerned in the production of alcohol.

The formation of alcohol by the action of nascent hydrogen on acetaldehyde has been previously suggested, by several workers, as occurring both during alcoholic fermentation by yeast and also during certain bacterial fermentations, and in the most recent theory of alcoholic fermentation to which I have already referred, this reaction has been postulated. Further reference to this point will be made in a subsequent lecture in connection with the bacterial production of Butyl alcohol and acetone.

The above and similar observations in the case of other organisms are of special importance, as shewing that given sufficient knowledge, it may be possible, as I have indicated above, to cause any one living cell to function in different directions, and that substances which have hitherto been regarded merely as by-products of the main change, may be produced in much larger proportions, and might even in some instances become the chief fermentation product.

With your permission I would like to follow this aspect of the matter a little further.

It will be remembered that in 1858, Pasteur first called attention to the constant occurrence of glycerine and succinic acid in the fermentation of sugar solutions. He found as the result of his analyses that from 100 parts of cane sugar 3.16 parts of glycerine and 0.67 parts of succinic acid were produced. From time to time numerous experiments were made with the object of ascertaining whether the proportion of glycerine could be increased by varying the fermentation conditions, or by working with yeasts of different species, and results in the neighbourhood of 7% and 8% were occasionally recorded. The subject, however, remained one of academic interest until during the recent war the production of glycerine in large quantities became a matter of vital importance to all the belligerent countries. As soon as the supply of fats shewed signs of being insufficient for the needs of the military authorities, other methods of making glycerine were actively studied, and among these the possibility of producing that most needed substance by a fermentation process. Having regard to the circumstances under which those investigations were carried out it is very difficult to say to whom precisely the credit of solving the problem (so far as it may be said to have been solved) is to be assigned. It seems clear, however, that early in 1917 the Germans were producing large quantities of glycerine in this manner, and probably the actual experiments were made very shortly after—if not before—the outbreak of war.

In a paper recently published in the Berichte der Deutschen chemischen Gesellschaft, Connstein and Lüdecke give some account of their experiments. Having found that the "direction" of fermentation in alkaline solutions was very different from that observed in acid media, they tried the effect of adding to the sugar solutions various alkaline salts, such as disodium hydrogen phosphate, ammonium carbonate, sodium acetate and sodium bicarbonate, and found that the yield of glycerine could be increased in this way to about 10 per cent. Great difficulties were at first encountered, owing to the rapid development of bacteria (especially those producing lactic acid) in the alkaline medium, and this was eventually overcome by the

employment of sodium sulphite as the alkalising agent. Working in this way they found that with 40 per cent. of sodium sulphite, the yield of glycerine reached 23 per cent., and that when the weight of the sulphite used was twice that of the sugar, as much as 36 per cent. of glycerine could be obtained. All fermentable sugars and all strains of yeast appeared to work equally well, and crude materials like molasses could be utilised. By working under suitable conditions, glycerine of a high degree of purity was obtained, and the process was ultimately handed over to the Army Authorities, who organised a Company which is stated to have made 1,000,000 kilograms of glycerine a month, the yield being from 20%—25% of the sugar used. According to a report from the laboratory of the Internal Revenue Bureau, Washington, dated May 6th, 1918, it is made clear that the American Authorities had also devoted themselves to this problem, and with considerable success. Dr. Alonzo Taylor, then Assistant Secretary of Agriculture, when in Berlin in 1917, became aware of the work which the Germans had been doing in this direction, and as a result of his recommendation, the investigation of the problem was commenced in the States at four different centres. To Mr. John Eoff, working in the laboratory of the Internal Revenue Bureau, belongs the credit of having worked out in America, a method for the production of glycerine in quantity from molasses, by a fermentation process. In these experiments, which are described in a report which came into my hands in the Summer of 1918, sodium carbonate was used as the alkalising medium, and its cheapness, coupled with the fact that much smaller quantities were necessary than in the case of sodium sulphite, appeared to give this process a great technical advantage over the German one. There, was, however, the drawback that yeast is very sensitive to the poisoning effect of sodium carbonate when used in excess, and that special means had to be taken to "acclimatize" the yeast to working under these abnormal conditions. This was effected by working progressively upwards from small quantities of liquid, and by adding the sodium carbonate (soda ash) little by little. *Saccharomyces ellipsoideus* was the yeast used in these experiments, and the sugar material was the "black strap" or Porto Rico molasses. The fermentations were conducted at a temperature of 30°—32° C., and occupied about five days. From 20—25 per cent. of the sugar taken was converted into glycerine, alcohol and carbon-dioxide being the only other products formed in any quantity. A weak point in the process is that only one-half of the glycerine formed is recoverable in a pure condition owing to the very impure character of the fermented wash, but this and other defects could no doubt be overcome in time. I am not in any way concerned with a criticism of the process from a commercial point of view. It may be just one of the many processes which came into being during the war and which would have only been practicable under the abnormal conditions then existing, such as absence of competition and the comparative unimportance of cost of production. What is, from my present point of view, of the greatest importance, however, is that by the application of the necessary study an ancient and very familiar biological process has been made to yield as much as 40% of a substance which had hitherto been regarded merely as an unimportant by-product occurring to the extent of about 3 per cent. Even if it should happen that, owing to commercial considerations, not another ounce of glycerine is produced by the fermentation of sugar, the lesson to be drawn ought to be of no less value to all who realise how perfect a mechanism the living cell is in effecting chemical change, and how comparatively little study has as yet been devoted to the aspect of the matter which I wish to emphasise this evening, namely, the ready response of the cell to its environment and the influence of that environment on the chemical products of its activity.

It has been shewn that glycerine is produced by yeast juice and zymin as well as by the living cell, and the bulk of the evidence available tends to support the view that it is actually derived from the sugar in the same manner as alcohol and carbon dioxide. The discovery of the enzymic nature of fermentation rendered it possible for the first time to distinguish clearly between those substances which are due to the actual fermentation process, that is the splitting up of the sugar molecule, and others which always accompany them, but which are, in fact, the result of metabolic processes connected with the life of the cell itself. Among the latter are succinic acid, and the higher alcohols, which together constitute the so-called fusel oil. Ehrlich by a series

of admirable experiments shewed that the higher alcohols are formed from the amino-acids present in the wort or other industrial liquid undergoing fermentation. One of the chief constituents of the fusel oil of fermentation is iso-amyl alcohol, and the close genetic relationship between this and the amino-acid leucine will be apparent on reference to the following structural formulae :—

Leucine

$$(CH_3)_2.\ CH.\ CH_2.\ CH\ (NH_2).\ COOH.$$

Iso-amyl alcohol

$$(CH_3)_2.\ CH.\ CH_2.\ CH_2.\ OH.$$

This relationship led to attention being directed to the possibility of the higher alcohols being derived from amino-acids, and experiments shewed that such was in fact the case. Thus leucine takes up the elements of water, and becomes converted into iso-amyl alcohol, ammonia and carbon-dioxide.

$$(CH_3)_2.\ CH.\ CH_2.\ CH\ (NH_2)\ COOH + H_2O$$
$$= (CH_3)_2.\ CH.\ CH_2.\ CH_2OH + NH_3 + CO_2$$

The ammonia formed in this reaction is at once assimilated by the cell and does not appear in the fermented liquid. This change is not brought about by yeast juice or zymase. In the case of succinic acid it would seem that we must also look to the amino acids as its source, but the mechanism by which it is produced is not apparently so simple. It appears to be formed from glutamic acid by a series of processes involving the formation of hydroxyglutaric acid as an intermediate product.

I should now like to refer to another example of the effect on an ancient industry of the application of modern biochemical methods.

The moulds, or many of them, contain, as is well-known, diastase in considerable quantity, and are consequently possessed of powerful starch-converting activity. Among the hyphomycetes the aspergillaceae and mucors occupy a prominent position in this respect. Moulds have, in fact, been utilised in the East from very early times for the conversion of starch in the production of wine or other products. Thus the so-called Chinese Yeast, largely used, as its name indicates, in China, for the production of potable spirit from rice, consists partly of the mould ***Mucor*** ***(amylomyces) rouxii***. In Indo-China it is sold in the form of small tablets known as "migen" or "men," consisting of a mixture of rice meal with cinnamon, cloves and other spices, and numerous yeasts and moulds. This Chinese yeast appears to have been first submitted to a scientific study about the year 1885, by Professor Calmette, who found that among a large number of organisms of various kinds several species of mould were constantly present, and it was to these that the starch converting action was due. These moulds, belonging to the Mucor group, were submitted to a searching and systematic investigation, and finally several species or types were isolated, obtained in pure culture, and tried on the industrial scale. Professor Calmette, with whose name the names of M.M. Boidin and Collette are inseparably connected in this matter, made the first large scale trials in 1898 in the distillery of M. Auguste Collette at Seclin, near Lille. The method in a few words consists in using certain moulds (*Rhizopus Delemar* or *Mucor Boulard* are now almost exclusively employed) in place of malt for the purpose of saccharifying the starch of the grain, and carrying out all the operations in pure culture, and under strictly aseptic conditions. The following is a brief outline of the process as carried out in a number of large distilleries on the Continent.

As a source of starch, maize, rice, manioc, or potatoes are most generally used. The grain or other raw material having been got into a fine state of division by suitable means passes into a steeping vessel, where it is treated with a sufficient quantity of water and a small amount of hydrochloric acid to react with the basic phosphate of the grain, and so to render the starch soluble and to prevent it from setting into a stiff paste, as would otherwise be the case. After a steeping period of about one hour at a temperature of 60°—70° C., the mixture is run into the Cooker. Into this vessel steam is admitted in such a way that at the end of about 20 minutes the pressure amounts to 60 pounds. The grain mixture is then kept at this pressure for about 15 minutes. In practice a second cooker is usually employed, the object being to render the gelatinisation or cooking of the grain more complete. From this vessel the "mash" is blown by steam pressure into the first fermenting vessel, which is a closed cylindrical vessel, in which the fermentation can be carried out without any risk of infection. These vessels have a capacity of from 20,000 gallons to 40,000

gallons or even more. The boiling hot mash is then cooled by running cold water over the outside of the vessel and filtered air is forced through it in order to supply the oxygen necessary for the growth of the mould. When the temperature has fallen to 40° C. (104° F.) the cooling process is stopped, and the pure culture of the mould to be used is added through a special tubulure. A litre of the culture containing perhaps about half a gramme of spores is sufficient for from 20,000 to 30,000 gallons, and it has been calculated that one gramme of the dry mould is sufficient to convert the starch in about 30 tons of maize. The contents of the vessel are maintained at a temperature of about 40° C., and at the end of 15—20 hours, the whole of the mass is penetrated by the mould mycelium. In order that the mould may have the necessary start so as to provide fermentable sugar, the yeast is not added at the same time, but some hours later. The two actions, that is the saccharification of the starch by the mould, and the fermentation of the sugar by the yeast, then proceed together, and at the end of about 30 hours, the fermenting wort may be transferred to open fermenting vessels, since both the mould and the yeast are then in such a vigorous condition that infection with air-borne organisms is not greatly to be feared. Mons. Delemar has, however, pointed out that the "mixed process" involving the use of open fermenting vessels is irrational, and that it is only to be recommended in times when the price of Alcohol is high, and when rapidity of production is the ruling factor.

When using open vessels—even under the best conditions—there is, of course, always the possibility of infection and, in addition to this, there is a certain loss of Alcohol owing to the fact that the escaping Carbonic Acid Gas is not passed through a washer, as when the fermentation is carried out in closed vessels. It has, moreover, to be remembered that, when once the fermentation is complete, there is great risk of the destruction of a proportion of the Alcohol by certain organisms, such as *Mycoderma vini*, if there is any delay in passing the wash to the Still.

These various sources of loss, according to M. Delemar, suffice to reduce the yield of Alcohol by from 1 to 2 litres per 100 kilos of Grain—that is to say, by from 2 to 3 per cent. of the total yield. The yeast used is a special species which has an optimum fermenting temperature of 38° C. (100.4° F.)—that is to say the temperature at which the mould enzymes are most active. The whole fermentation process takes about four days, and at the end of the process the wash is passed to the still for distillation. There are several modifications of this process, and, of course, the exact working details have to be adapted to the nature of the raw starchy material used, but my object has been to give merely a brief sketch of the method, so that the biological process involved may be better understood. The yield of alcohol is with good working said to be as high as 97.5 per cent. of the theoretical, a result which was confirmed by (among others) Horace Brown, Roscoe and Macfadyen. This is higher than by the usual methods, since unfermentable dextrines are not formed in the process of saccharification, as is the case when malt is used as the converting agent. The quality of the alcohol is also superior there being less foreshots and tailings, and considerably less fusel oil is produced than in fermentations carried out in the ordinary way.

As shewing the progress made by this so-called "amylo" process since its introduction some 20 years ago, and as indicating the extent to which it is now employed, it may be mentioned on the authority of M. Delemar that a quantity of absolute alcohol approximating 6 million hectolitres has been prepared. Of this France has produced about 2½ millions, Spain about 1 million, Italy about ¾ million, America about ½ million and other countries the remainder. In 1916, according to M. Paul Baud, the output in France alone amounted to 665,232 hectolitres, as against 880,821 litres in 1912. These figures will suffice to show the value and the potentialities of this purely biological process, and indicate very clearly the lesson which is to be learned. It will be seen that by biochemical research and by the application of modern scientific methods a crude process of very limited application and dating almost from time immemorial, has in the short space of 20 years, been raised to the position of one of very high technical importance to the whole world. So long as alcoholic fermentation takes place in accordance with what is usually known as Pasteur's equation, it is clearly impossible to hope for very much better yields by the

amylo process than those at present obtainable, but M. Delemar (whom I have already quoted on several occasions and who can claim to speak with very great authority on this matter) thinks it probable that the process is capable of development in other directions. He is of opinion that, by accustoming suitable moulds to growth in solutions containing fluorides, or perhaps other antiseptics, it may be possible—as he has already shewn on a small scale—to increase very materially the rapidity of the process. He has, in fact, expressed the opinion that it may be possible, one day, to produce from 1,000 to 1,200 kilos of sugar per hour in a 1,000-hectolitre vat in place of the 200 to 800 kilos at present produced in that time.

It seems probable, moreover, that other directions in which improvement is to be looked for consist in finding a means of thoroughly "cooking" the grain without producing any caramelisation, and in supplying cheaply an amount of nitrogen of the right kind sufficient for the rapid development of the organisms used.

In any case, the process is clearly one not merely of scientific interest, but of very great practical importance, since there can be no doubt that for many years to come the world will have to depend chiefly on fermentation for its supply of alcohol. Whatever views we may hold about alcohol as a beverage it is abundantly clear that for industrial and power purposes, it is becoming a commodity of the highest national importance. Before long indeed its consumption for industrial purposes may come to be regarded, like that of sulphuric acid and soap, as an indication of the degree of civilisation to which a country has attained. It may perhaps be added that in this country the amylo process is not available, owing to certain Excise Regulations. It is to be hoped, however, that the Excise Authorities will do everything possible to remove this reproach and that they and other Government Departments will do all in their power to encourage the application in this country of the latest teachings of science to industrial practice. If they do not, the handicap will be too great, and we shall have to be content to take a second place and to see other countries outdistancing us in the race. No Government can afford to ignore scientific discoveries and industrial developments which are taking place under their very eyes, and if there is one thing which, during recent years, has been made more apparent than another, it is that the country which is foremost in the encouragement of its scientific men and in the utilisation of their discoveries will ultimately win the race at the expense of those which have been more neglectful in that respect. The possession by the latter of greater natural resources will only serve to stave off defeat for a time.

THE BRISTLE INDUSTRY OF RUSSIA.

Prior to the war. Russia supplied 55 per cent. of the world's production of bristles, and was the main source of the extra-fine grades of this product. The other important producing countries were China and India. Owing to the superior quality of Russian bristles they commanded a higher price than the Chinese, and for that reason Russia took first place in the value of bristle exports. Germany appeared to be a large exporter of bristles for the reason that Russian stocks were marketed by German merchants. The very finest grades of bristles come from Siberia, from the region between the Ural Mountains and the Lena River.

According to a Memorandum prepared by the Russian Division of the United States Bureau of Foreign and Domestic Commerce, the difference between the American and the Russian methods of feeding hogs is as follows:—In America they are fed in pens on corn and other foods, while in Russia they run freely on pastures and fields and around the villages and are fed on domestic food refuse. Owing to the systematic feeding in the pens, the American hogs are ready for slaughtering within a few months, while in Russia it takes several years. Russian bristles grow coarse and long, first, because the pig spends the greater part of his life in fresh air on pastures, and, second, because of the comparatively cold climate, particularly in Siberia.

As the means of transportation to isolated villages scattered over the vast plains are inadequate, the bristles are kept by the peasants until the coming of some itinerant purchaser, perhaps a pedler, who barters for the goods. From the pedlers the bristles are passed on to the dealers, in the principal centres, such as Petropavlovsk, Omsk, Novonicolaievsk, and Barnaul in Siberia.

Often not more than 200 pounds are obtained annually from a village, but from these small supplies large stocks of raw and prepared bristles are assembled, with other commodities, at the fairs, which, because of the difficulties of travel, are so important to the commercial life of Russia. A large part of the Siberian bristle production is disposed of at Irbit, where a fair is held each year in February. The fair at Nizhni Novgorod, held annually from the

last week in July until the middle of September, is the best known. It is the collecting centre for north-eastern Russia and Siberia and is attended by bristle buyers from all parts of the world. In 1916 bristles brought to the fair amounted to about 180,000 pounds, and were disposed of at varying prices, ranging from 1s. 8d. to 3s. 4d. a pound for ordinary bristle to as high as 8s. 4d. a pound for selected grades.

The preparation of the assorted bristles is mainly in the hands of the Jewish population of the cities, who own small bristle factories, where workers sort, straighten, turn and drag the bristles. The chief centres for the preparation of bristles are the many towns in the north-western Provinces of Minsk, Vitebsk, Vilna, Kovno, Baltic Provinces, Poland, and the Ukraine. The essentially Jewish character of the Russian bristle industry was the principal cause for the bristle market being held at the Leipzig fairs in Germany, where the Russian Jews had the right to enter without any restrictions. Although Petrograd was in many respects another important centre for bristle exportation, the restrictions on Jewish traders entering Petrograd prevented that city from being the principal trading centre for bristles.

Even before the war a peculiarity in the export of Russian bristles was the fact that though the world distributor and largest consumer of Russian bristles was London, yet Russian bristles went to London by way of Leipzig. The World War eliminated Leipzig, but London is still the principal world market for this article. Before and during the war the United States received most of its bristles from England.

There is a world shortage of bristles, a fact which in no small way is due to the present insignificance of the Russian supply. Most of the bristles now being received from Russia come from the Ukraine, and are bringing record prices, as did the last shipment from Siberia. South Russian bristles are reported as selling at a low price on account of their being unsorted. During the war pigs were practically exterminated in Poland, Ukraine and western Russia, famine being the chief cause of their destruction. Therefore, future supplies will be very small compared with pre-war days.

The stocks accumulated during the past five years must not be overestimated, as the effect of not having an immediate market has been to make the peasants careless in their collection and storage. In Poland there are fairly large stocks, but the Polish Government, wishing to encourage local brush manufacturing, has placed an embargo upon their export.

The following table shows the quantity of bristles exported from Russia, by countries of destination, for the years 1910 to 1915:

Countries of destination.	1910	1911	1912	1913	1914	1915
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Austria-Hungary	891,336	1,098,768	848,254	863,746	710,483	....
United Kingdom	621,971	506,735	570,329	265,068	305,948	1,999,096
Germany	3,609,763	3,898,377	4,436,494	4,288,828	2,139,250	....
Finland	179,444	207,215	116,969	130,945	175,436	1,162,182
All other	91,257	114,694	90,788	183,706	139,576	264,093
Total	5,393,771	5,825,789	6,062,834	5,732,293	3,470,693	3,425,371

ITALIAN SUMAC PRODUCTION.

Sicily is the largest producer of sumac in the world, followed by the United States. The annual output in recent years, writes the United States Vice-Consul at Palermo, is estimated at 15,000 tons, a decrease of 50 per cent., compared with pre-war production, due to the lack of cultivation brought about by war conditions. However, it is believed that this is only of a temporary nature, and with the increased demand there is expected to be a consequent increase in cultivation.

Sumac is of two kinds—male and female. The male species, which is found in the Provinces of Palermo and Girgenti, contains 28 per cent. or more of tannin, and is, therefore, the better of the two. The female leaf averages about 24 per cent. tannin and is generally found in the Provinces of Catania and Girgenti. Both species thrive throughout the island at any elevation up to 2,000 feet.

There are about eight large sumac-grinding mills in Palermo. No works for the manufacture of sumac extract are established there, but it is believed that with the present indication of a revival of the sumac trade such works will be constructed, and plans to this effect have already been made. Exportation from Palermo is made chiefly to Great Britain, United States, France and Germany.

CAMPHOR INDUSTRY OF FOOCHOW.

In the course of a report dealing with the camphor industry in his district, the United States Vice-Consul at Foochow states that trees fit to be used for camphor distillation must be at least 20 years old. When a suitable tree is found a crude native distillery is set up at the spot. This consists of a boiler, with an iron base and a wooden top, connected to a distilling vat partially filled with water. The camphor upon being conducted to the vat precipitates as crystals on the inner walls, while the nonprecipitable portions drop down as oil, which floats upon the water. About 5¼ pounds of camphor and camphor oil, in the proportions of 70 per cent. camphor and 30 per cent. camphor oil, can be produced from 240 pounds of chips. The districts where most of this initial distillation is done are Kienning, Yuchi, Yungan, Yenping, Tatien, Shaowu, Shahsien, and Ningte. The crude product is carried by porters to the Min River, or one of its tributaries, and then carried to Foochow by native boat.

The marketing of camphor is done very largely through brokers in Hongkong. The distilleries seldom do their own marketing, with the exception of the Japanese and Portuguese.

It should be borne in mind that the camphor market is an extremely sensitive and dangerous one for the uninitiated.

The product as it leaves the distillery in the interior consists of crystals and camphor oil. The crystals are ready for marketing, but the oil is put through a process of redistillation at Foochow. This process is a simple one, and need not be described in detail. The effect is to distil from the oil all the remaining camphor; 133 pounds of oil produce 64 pounds of camphor and 27 pounds of desolated oil. The camphor derived from oil is of a cheaper grade than that derived originally from the wood chips. The desolated oil is used as a base for dyes and paints.

There are 12 of these distilleries in Foochow which produce camphor from the oil. When working, each distillery produces on an average 325 pounds of camphor a day.

The various districts producing camphor have each an official camphor bureau under the control of the Provincial Commissioner of Industry. Each bureau has the authority to collect within the district it covers certain taxes and to buy camphor trees and distil camphor. The tax is approximately 25s. every 133 pounds of camphor in transit. The taxes collected and the camphor produced are sent to another Government bureau called the Fukien Government Camphor Industry, Transportation, and Tax Collection Office. Its duties are to take in and turn over to the provincial Government the taxes remitted by the various district bureaus and to take in and market the camphor received.

There is still a third bureau which has authority to buy camphor oil and distil it into camphor, marketing its product independently.

Private producers must take out licences and agree to pay the taxes above mentioned. There is also a licence fee of 2 dollars local currency per month per vat.

Foreigners wishing to go or send into the interior to purchase camphor under what is known as the "transit pass" system, permitted by treaty, may still do so. Under this system the foreign exporter may bring the native product to the seaboard and export it to a foreign country by paying the regular 5 per cent. export duty plus a surtax of half the export duty. The foreigner may purchase either from the private producers or from the Government bureau. The effect of the Government bureau system is to tax the product just the same, because the foreigner may not operate his own distillery in the interior, and Government taxes are imposed on the distillery and its product before the foreigner purchases the camphor.

Japanese distilleries operating in the city of Foochow are not taxed, according to information given by the Japanese consulate in Foochow.

ITALIAN PUMICE INDUSTRY.

Pumice is formed by the solidification of the foam produced on molten lava by the escape of gases. The internal structure of high-grade pumice is cellular and the specific gravity of the stone so low that dry pumice floats in water. While pumice is scattered over considerable areas of the world's ocean bed, the known deposits on dry land are not extensive.

The highest grade of pumice known to the trade is of Italian origin. The seat of the industry is the volcanic island of Lipari, one of the group of the Æolian Islands lying off the north coast of Sicily about 40 miles from the Italian mainland. The town of Lipari, with a population of 10,000 inhabitants, is said to be one of the most prosperous communities in Italy, as 90 per cent. of the pumice mines belong to the municipality, and the city collects an export duty in normal times amounting to a total of not less than 300,000 lire annually.

The methods employed in pumice mining are primitive. The deposits for the most part are found near the surface, and the material is extracted by drifts projected only a few metres into the hillsides. From a report written by the U.S. Commercial Attaché at Rome, it would appear that the output could be considerably increased if these drifts were properly timbered so as to follow out the paying strata of pumice material. Without the use of props the danger of caving in is such that the mining drifts are abandoned long before their possibilities are exhausted.

Before the war the work in the mines was performed chiefly by convicts who had been sent to the island for petty misdemeanours. These men were free to go about as they chose during the day, but were locked up from sunset to sunrise. As they were allowed only a few cents per day for maintenance, they sought employment in the pumice industry, as there was no other lucrative occupation on the Island. These men had no interest whatever in their work and, as grinders of pumice, turned out a very inferior article. During the war the convicts were sent to another island and the work has since been carried on with better results by the native islanders. Despite the higher grade of labour now employed, locally-ground pumice is still considered an inferior article. This explains the fact that crude lump pumice commands a higher price in the American market than that sorted and ground by the Italians.

Roughly speaking, pumice is divided into three grades. (1) The crude material as it is taken out of the mine is known as "pumice chips" or "pezzame" and forms about 80 per cent. of the total exports to the United States. (2) Italian powdered pumice is a product of the local mills and is handled in bags for the export trade. The bulk of the exports to Great Britain, France, and countries other than the United States is in this form, the United States being the only country where the crude produce is imported and converted into pure powdered pumice. (3) Lump pumice varies from the size of an apple to that of a large cabbage. This grade is shipped in barrels and is used principally by carriage and motor car builders, marble workers, lithographers, platers, and manufacturers of patent leather and enamel.

The pumice trade was naturally interrupted by the war and exports dwindled. During 1919 the shipments of pumice from Lipari were greater than ever, the quantity and destinations being as follows:—

	Kilos.
To Mainland of Italy and Sicily	5,805,684
,, France	3,257,148
,, England	1,451,381
,, United States	7,531,693
,, Germany	198,369
Total	18,244,275

Exports are rapidly increasing. It is understood that in the six months, January to June, 1920, one firm on the island of Lipari shipped 4,000,000 kilos (kilo = 2.2046 pounds) of pumice to the United States. There are about 20 firms on the island of Lipari engaged in the pumice export trade: and, being unorganized, competition among them is active. It is seldom that an ocean-going vessel stops at Lipari to take on a cargo, as the island possesses no harbour facilities. While occasionally consignments are lightered out to steamers on small barges, the bulk of the export shipments is handled through the port of Messina. On vessels returning to the United States from the Adriatic and Black Sea ports advantageous rates may sometimes be obtained for non-perishable goods such as pumice.

If modern mechanical devices for mining were employed and better methods adopted in the grading and preparation of the raw material for the export trade, a great expansion of the business, in the opinion of the Commercial Attaché, might be reasonably anticipated. At the present time the industry is strictly localised and self-contained, and it is likely that American importers will continue to display a preference for the lump pumice rather than for the powdered article as it comes from the hands of the native grinders.

PRODUCTION OF NITROGEN FERTILISERS IN GERMANY.

Calcium cyanamide factories engaged in the production of nitrogen fertilisers by process of fixation of atmospheric nitrogen were in operation in Germany before the war, but during the war these plants were extensively enlarged and are now in process of completion. The total output of these plants when properly supplied with coal is estimated at 600,000 tons, with a nitrogen content of 120,000 tons. Several plants representing this production, together with the possible output of each, are as follows:

	Tons.
Mitteldeutsche Stickstoffwerke A. G. Piesteritz	175,000
Oberschlesische Stickstoffwerke A. G. Chorzow	150,000
Aktiengesellschaft für Stickstoff-duenger, Knapsack, Gross Kayna	140,000
Bayerische Stickstoffwerke A. G., Trostberg and Margarethenberg	75,000
Lonzawerke, Waldshut	60,000
Total	600,000

At the beginning of this year, according to information furnished to his Government by the representative at Berlin of the United States Department of Commerce, these plants were producing approximately 500,000 tons of calcium cyanamide, with a nitrogen content of 100,000 tons.

Prior to the war the production of nitrogen fertilisers by coke and gas industries reached a figure of 580,000 tons, with a nitrogen content of 116,000 tons. However, the coal shortage has militated against the maintenance of production at these figures.

The Badische Anilin und Sodafabrik is the only concern producing nitrogen fertilizers by the Haber-Bosch process. Its first factory for this purpose was constructed at Oppau. Operations began at this plant in 1913. A second

plant known as the Ammonia Works of Merseburg, which is twice the size of the Oppau plant, was later erected, and has been in operation since 1917. When properly supplied with raw material, the annual output of nitrogen in both of these plants is 300,000 tons, corresponding to 1,500,000 tons of sulphate of ammonia.

Before the war Germany's annual agricultural requirements of nitrogen fertilizers were 210,000 tons of nitrogen, of which 100,000 tons were in the form of nitrate of soda and nitrate of lime (imported), 100,000 tons in the form of sulphate of ammonia from home production, and 10,000 tons in the form of calcium cyanamide, likewise of home production. At the outbreak of the war there were only 40,000 tons of nitrate of soda within the country, which were immediately taken for the manufacture of ammunition. The total production of nitrogen fertilizers by the plants now existing, and those in process of construction, will approximate 500,000 tons of nitrogen, equal to more than twice the amount required for agricultural purposes before the war.

In spite of their high cost, nitrogen fertilizers are in great demand in Germany. A quantity of sulphate of ammonia containing one kilo of nitrogen cost 1.35 marks in 1913, as against 12 marks in 1920. At the same time, 100 kilos of ammonia fertilizer with 20 per cent. nitrogen, cost 27 marks in 1913 as against 240 marks in 1920.

THE BASKET INDUSTRY IN GALICIA.

Under the name National Industrial Union there was established in Lwow (Lemberg), 20 years ago, an institution for supporting basketwork and the textile industry. Before the war the authorities of Galicia financed the Union, which used the funds so appropriated to uncrease its reserve capital. In 1920 the Union was transformed into a limited company with a stock capital of 2,000,000 marks, which it was decided to raise to 10,000,000 marks.

At present, according to "Commerce Reports," the Union directs several basketwork houses, textile mills, woollen factories, and fur factories in Little Poland (Galicia). To sell these goods the Union possesses its own markets in Lwow and Krakow. Later, on the initiative of the Union, a basket syndicate was established for exporting its goods. An account of this syndicate appeared recently in the local press, the substance of which is given below:—

The basket industry in Galicia alone employs some 15,000 basket makers. In 1920 the various basket-weaving concerns of Galicia combined in one corporation known as the Basket-Weavers' Syndicate (Syndikat Koszykarski), with a capital of 5,000,000 marks. Favourable exporting conditions for basketwork have led the corporation to increase its capital to 10,000,000 marks.

The syndicate has opened agencies and branches in the most important market centres, and negotiations have begun from English, French, German, Italian, Dutch, Rumanian, and Turkish interests. The Poles in America are organizing a similar corporation, which will endeavour to interest the American market in Polish basket ware. An important Czecho-Slovak financial institution has offered a large credit to the syndicate for opening branches and agencies in Czechoslovakia. The Galician Bank (Bank Malopolski) is taking an active part in aiding the development of the syndicate, and negotiations have also begun with the Polish Commercial Association (Polskie Towarzystwo Handlowe).

The willow-preparing industry, a department of the Basket-Weavers' Syndicate, is also rapidly developing, and a project for constructing 10 willow-wood steaming plants is under consideration to supply needed raw materials for weaving.

This development of Poland's basket industry is creating a large demand for willow, and during the last few years private initiative has been trying to encourage its planting. The demand for basket willow is so great, both abroad and in Poland, that considerable misunderstanding has arisen between willow dealers and basket manufacturers, the former wishing this wood for export and the latter demanding that the supply be guaranteed to the Polish basket industry and only surplus be allowed for export. The Ministry of Industry and Commerce has ordered the export of willow to be suspended for the time being until full reports are made on production and consumption of willow in Poland. On the basis of these reports the Ministry will decide whether or not to permit export of willow and in what quantities, so that the Polish basket industry may not be placed at a disadvantage.

CORRESPONDENCE.

ORTHOTYPE.

Mr. Hayes has seen very few specimens of the Orthotype Print, so that his misunderstanding of the system is quite natural. I have *never* suggested to *teachers* to cover the vowel letters except for the first two or three minutes of reading, in order to convince themselves that Orthotype is NOT a diacritical method.

As this is not my scheme at all, it cannot be a grave fault; on the contrary, the marks serve to attract the attention of the pupil to the irregular spelling and so serve as "danger signals."

When first published by the Knowledge Company, and by the advice of the Minister of Education in Canada, the Orthotype speci-

mens had the signs incorporated with the print, for the very purpose of teaching the Chinese the nature of an alphabet.

I should be pleased to show these specimens to Mr. Hayes or to anybody interested in this most important subject of Printing Reform for International English. The only object of placing the marks above the print is to enable every English person to write to a foreigner without altering his handwriting, and with the same ease with which he dots the "i" and crosses the "t." Orthotype is not only a script, but a feasible method of Printing Reform.

A. DEANE BUTCHER.

GENERAL NOTES.

INDIAN TIMBERS. — A correspondent of *Indian Engineering* lately complained that Professor R. S. Troup in the paper on "Indian Timbers" which he read before the Indian Section of the Society on January 21st (*Journal* vol. LXIX. p. 177), dealt largely with the question of export to the United Kingdom, and said little about utilising these timbers in India itself. Another correspondent of the same paper, replying to this criticism, points out that Professor Troup's paper was read to the Royal Society of Arts, and says it may be presumed that the audience consisted mainly of retired officers and persons interested in the timber rade in England. It was, therefore, natural that Professor Troup should confine himself more especially to that part of the subject which directly interested his audience. The writer continues:—"Anyone who has been in close touch with the evolution of forest utilisation during the last 20 years or more, knows that year by year new species of timber have been brought on to the Indian market. To cite only one instance; in 1900 the only timbers exploited in quantity from the coastal forests of Kanara were Teak, Blackwood, and a small quantity of Mutti (*Terminalia tomentosa*) and Nana (*Lagerstrœmia microcarpa*). By 1910 Kindal (*Terminalia paniculata*) Honne (*Pterocarpus Marsupium*) and Jamba (*Xylia Xylocarpa*) were added to the list, while to-day another 10 or 12 species are saleable, and are absorbed by the Indian market." He admits that for years the timber trade in India has been extremely conservative, owing to its always having been educated on Teak, Sal and Deodar, but he claims that the movement to utilise other species "is in a far more advanced state than the question of export, which is one of quite recent growth."

MOTOR TRANSPORT LINE IN SPAIN.—The longest motor transport line in Spain, according to *The Engineer*, was recently opened from Santander to Burgos. The distance between the two towns is 96 miles, and the road is of a very difficult character, for starting from sea level it rises to a height of 3,280 feet at Puerto del Escudo, and drops down abruptly to Burgos. In certain places 18 per cent. gradients are encountered. The line will carry both passenger and goods, the regular daily service being assured by four Fiat omnibuses and four lorries of the same make.

OIL FROM SICILIAN ASPHALT.—On the authority of a Rome newspaper the U.S. Commercial Attaché at Rome reports that an Italian company for the production of schist oil on a large scale possesses one of the rich centres of the asphalt deposits of Sicily, and, in addition to working the material up into paving and roofing products, has developed a process for obtaining mineral oil with an exceedingly low bituminous content. The process has recently been perfected by Italian engineers and employs a large battery of gas furnaces. The low fuel value of the product is overcome by recovering almost completely the latent heat of the ash by means of a current of the inert gases from the condenser discharges. Another novel step in the process is the recovery by means of centrifugal filters and condensers of the oil particles which the combustion fumes carry in suspension. In this way an oil is obtained which may be used as a fuel, having as much as 10,300 calories per kilogram. The company is planning the construction of a large oil refinery near Rome. The 1920 production is estimated to be 5,000 metric tons of mineral oil and it is expected to increase this to 10,000 metric tons during 1921.

THE SALT INDUSTRY OF CURAÇAO.—The manufacture of salt in Curaçao and other islands of the Dutch West Indies, principally those of Bonaire and St. Martin, is quite an important industry and is carried on extensively at a comparatively small cost. The product, known as "sola salt," is manufactured simply by the evaporation process which takes from four to five months. At present, writes the United States Consul at Curaçao, some 12 different companies are engaged in its production on the island of Curaçao. One of the largest companies, the St. Nicolas estate, which has an area of about 490 acres, is situated almost at the extreme west end of Curaçao, and comprises 12 salt ponds. It is estimated that the yearly production of the estate is about 40,000 barrels (1 barrel = 286 pounds). These ponds, which have an average depth of 3 feet, are filled with sea water through an artificial canal about 3,280 feet in length leading direct from the ocean, and when full are closed by a dam. The canal is also used for transporting the salt to the shore, where there is a warehouse which will store some 7,000 barrels. At the ponds on Curaçao no process is employed by which the pure salt is separated from the magnesia and potassium salts, although this separation process is followed at the salt ponds of Philipsburg, on the Island of St. Martin.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2)

REPORT ON THE "OWEN JONES" PRIZES COMPETITION.

With the kind assistance of the Director of the Victoria and Albert Museum, the Council again arranged for a competition of students of Schools of Art in accordance with the terms of the Owen Jones Trust. Notices were issued in October last stating that six prizes would be offered under the usual conditions, each prize consisting of the Society's Bronze Medal, and a copy of a book or books on Applied Art, of a value not exceeding £2, to be selected by the successful competitors. In addition to these, a Special Prize of £20 was offered for the best design (irrespective of class) submitted. The subjects of the competition this year were :—

Book Production and Ornamental Leatherwork : Including Covers and Lining Papers for Bookbinding, Title Pages, Lettering and Printing, Posters, Trade Labels and Advertisements.

Metalwork : Including work in Precious Metals, Ironwork, Jewellery, Enamelling, etc.

Wallpapers, and other Mural Decorations.

Textiles : Including Damasks,* Brocades for Decoration and Furniture, Printed Fabrics for Hangings, Vestments and Church Fabrics (including Altar Frontals, etc.), Figured Velvets and Figured Muslins.

The date for the receipt of competing designs was fixed for June 25th, 1921, and arrangements were made for their inspection at the Victoria and Albert Museum.

The following judges were appointed by the Council to consider the designs submitted :—Mr. C. Harling Comyns, Mr. A. F. Kendrick (Department of Textiles, Victoria and Albert Museum), Mr. Martin Hardie, R.E. (Department of Engraving, Illustration and Design, Victoria and Albert Museum), Mr. G. H. Palmer (Librarian, Victoria and Albert Museum), Mr. John Slater, F.R.I.B.A., Mr. W. W Watts, F.S.A. (Department of Metal Work, Victoria and Albert Museum), Sir Frank Warner, K.B.E., Mr. James Yeo (of Messrs. Debenham). Mr. Emery Walker and Mr. Metford Warner were also appointed, but were unable to attend.

The competition was in former years conducted by the Board of Education in connexion with the National Competition, but since 1917 it has been conducted by the Royal Society of Arts. The judges have much satisfaction in reporting that there is a large increase in the number of competing designs received this year over those of the last four years, as the following figures show :—

Year.		No. of designs	No. of competitors.	No. of Schools presenting candidates.
1917	..	120	73	22
1918	..	37	31	9
1919	..	50	31	9
1920	..	94	63	17
1921	..	237	181	36

In addition to the increase in quantity there was also a considerable advance in the general standard of the work submitted.

The centres represented were [the figures in brackets show the number of competitors in each case] :—Belfast (1); Dewsbury (5); Exeter (1); Glossop (3); Halifax (1); Hyde (4); Ipswich (3); Leeds (18); Liverpool (15); London :—Acton and and Chiswick Polytechnic (1); Camberwell School of Arts and Crafts (4); Central School of Arts and Crafts (9); Clapham (1); Ealing (8); Hammersmith School of Arts and Crafts (21); Holloway, Northern

* Designs for Bedspreads, Table Covers, Cushion Squares and Tea Cosies were eligible.

Polytechnic (3); Hornsey (8); Leyton (6); Putney (10); Regent Street Polytechnic (1); Royal School of Art Needlework (1); Willesden Polytechnic (1); Macclesfield (8); Manchester (5); Morecambe (1); Nottingham (15); Reading (4); Shrewsbury (1); Skipton (2); Southampton (2); Southend-on-Sea (2); Stockport (1); Stroud (1); Torquay (1); Watford (11); West Bromwich (2).

The designs submitted were divided as follows:—Textiles, 82; Book Production, Printing, etc., 82; Wall Papers and Mural Decorations, 43; Metal Work and Jewellery, 30.

There were also two rugs submitted, but these were not considered eligible by the Judges under the terms of this year's competition.

In view of the high standard of the work, as well as the large number of entries, the Judges recommend that seven prizes be awarded instead of the six offered. The awards are as follows:—

Prizes.

Textiles.

Godfrey, William Frederick, School of Art, Watford (Design for a Printed Linen).

Jarvis, G. L., School of Art and Design, Nottingham (Design for a Machine-made Lace Bedspread).

Suthons, Elsie, Municipal School of Art, West Bromwich (White Linen Cushion Cover in Cut Work).

Swindells, Albert, School of Art, Macclesfield (Designs for Linen Damask D'Oyleys).

Book Production, Posters, etc.

Evans, H. S., School of Art and Design, Nottingham (Design for a Poster).

Mural Decoration.

Bacon, Miss K. A., L.C.C. Hammersmith School of Arts and Crafts, Lime Grove, Shepherd's Bush, London (Design for Mural Decoration).

[In the lettering above and below this design the separate letters are in many cases well proportioned, but their general arrangement and grouping are unfortunate, and there seems to be a needless eccentricity which should be eliminated. The design, however, in the opinion of the judges, shows very considerable promise.]

Metal Work, Jewellery, etc.

Samuels, Liela M., Municipal School of Art Cavendish Street, Manchester (Pendant in Gold and Plique-à-jour enamel).

Special Prize.

The Special Prize of £20 is divided equally between H. S. Evans, School of Art and Design, Nottingham, and Miss E. Suthons, Municipal School of Art, West Bromwich, for the designs mentioned above as being submitted by them.

Commended.

Textiles.

Anderson, Aileen, School of Art, Hyde (Stencilled Portière).

O'Brien, Peter, Municipal School of Art, Cavendish Street, Manchester (Design for a Machine Printed Cretonne for Hanging).

Clarke, D. P., School of Art and Design, Nottingham (Design for Machine-made Lace Bed Spread).

Dawson, Norman, School of Art, Macclesfield (Printed Velvet Hanging).

Evans, Fred, School of Art, Macclesfield (Design for a Woven Linen Damask Tea Table Cloth).

Falshaw, Alice, School of Art, Morecambe (Design for a Printed Silk).

Little, Lilian, School of Art, Glossop (Stencilled Bed Spread).

Langhorn, William F., School of Art, Dewsbury (Design for Printed Fabric for Hanging).

Lynn, Frederick, School of Art, Dewsbury. (Design for Damask Table Cloth).

Pritchard, Helen, School of Art, University College, Reading (Design for Chintz).

Sutherland, Evelina M., City School of Art, Liverpool (Design for Printed Cotton).

Thurgood, Iris, School of Art, Technical Institute, Leyton, E. (Design for Stencilled Cushion Cover).

Book Production.

Dillnutt, W. A., L.C.C. Camberwell School of Arts and Crafts, Peckham Road, London, S.E. (Hand-tooled Binding).

Evans, H. S., School of Art and Design, Nottingham (Design for a Title Page).

Franks, Catherine E., School of Art, Technical Institute, Leyton, E. (Design for a Tail Piece).

Jennings, E. Owen, School of Art, Leeds (Hand-tooled Book Binding).

Turner, E. H., L.C.C. Camberwell School of Arts and Crafts (Hand-tooled Binding).

Vallance, H. T., School of Art and Design, Nottingham (Design for a Poster).

Wood, Ruth M., School of Art, Exeter (Illuminated Service of the Holy Eucharist).

Mural Decoration, etc.

Hewitt, Muriel, City School of Art, Liverpool (Design for Embroidered Tapestry Panel).

Metal Work.

Whiteside, Winifred M., L.C.C. Central School of Arts and Crafts, Southampton Row, London, W.C. (Silver Chalice).

Arrangements have been made for the exhibition to the public of the competing designs as in previous years. They are now and will remain on view until September 17th, from 10 a.m. to 5 p.m. (on Sundays from 2.30 to 6 p.m.) in Room 132, Department of Textiles, Victoria and Albert Museum, South Kensington, S.W.

In announcing the awards the Council desire to express their thanks to the judges for the trouble they have devoted to the work and for the promptitude with which the awards have been made.

They wish also to state their appreciation of the assistance rendered to the Society by the Director of the Victoria and Albert Museum and his staff.

The full conditions and arrangements for the Competition in 1922 will be announced later.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURE.

MICRO-ORGANISMS AND SOME OF THEIR INDUSTRIAL USES.

By A. Chaston Chapman, F.I.C., F.R.S.

Lecture II.—*Delivered December 13th*, 1920.

In my last lecture I dealt at some length with the Amylo Process for the production of alcohol, and pointed out that the enzymes secreted by the moulds employed are very similar (if not identical) in their nature and in their functions to those secreted by germinated barley, that is to say, to those existing in malt.

The great technical advantage and economy involved in the use of a small quantity of mould in place of a much larger quantity of expensive malt will be apparent, but there is one defect common to both processes, namely, the loss of a considerable proportion of the valuable nitrogenous constituents of the grain employed — the quantity amounting, on a rough estimate, to 30 or 40 per cent. of the total nitrogen.

In addition to this, both processes involve a very thorough cooking of the raw grain, under pressure, in order to effect the complete liquefaction of the starch, and so render it amenable to the action of the saccharifying diastase of the malt or of the moulds above referred to. This cooking process not only increases the cost of working, owing to the large quantity of fuel used, but it has also the further disadvantage of increasing the proportion of soluble nitrogenous substances above that required for the nutrition of the yeast, and this nitrogen ultimately passes into the spent lees, and is so wasted.

In order to obviate these defects, Messrs. Boidin and Effront have introduced an important improvement in making use of the starch-liquefying enzymes secreted by certain bacteria. The bacterium found most suitable for the purpose is a certain strain of *B. mesentericus*, and by cultivating this in an alkaline medium in the presence of a considerable amount of oxygen, its starch-liquefying activity is enormously increased.

It has, in fact, been found possible to obtain a preparation of the bacterial enzyme of such a strength that it is capable of liquefying 1,000 times its weight of grain, and by concentrating the culture medium under reduced pressure, it is possible to obtain a liquid still more active.

In this process, the grain is soaked in a dilute alkaline liquid, is then coarsely ground, and the ground mass—to which twice its volume of water has been added—is heated to a temperature of 75° to 80°C.

The solution of the starch-liquefying enzyme is then added, and allowed to act for from half-an-hour to one hour, at the end of which time the whole of the starch will have become liquefied. It is then transferred to the cooker, from which it passes to the fermentation-vat, where it is cooled and treated as previously described, either malt or mould being employed.

When working in this way, the amount of nitrogenous matter formed by the proteolytic enzymes of the mould is much smaller than in the ordinary amylo process, and it is stated that an increased yield in alcohol, amounting to about two litres per 100 kilos of grain, is obtained.

The wort, which in the ordinary process contains more than 1 gramme of soluble nitrogen per litre, contains only from 0.1 to 0.3 gramme, the remainder of the nitrogen passing into the spent grains, and so increasing its value as a food for cattle.

Special interest attaches to this method, for it will be seen that it involves the active co-operation of representatives of three classes of micro-organisms, namely, moulds, bacteria and yeast, each organism producing the appropriate and needful enzymes.

I have referred specially to this process, not merely as representing an improved technical procedure, but because it shows in what way the technologist may benefit by the extended study of micro-biology and, incidentally, because it furnishes still another example of the possibility of acclimatizing organisms to new conditions, and causing them to modify their functions according to the environments in which they are compelled to work.

As a further example of this I may, perhaps, refer to the manufacture of citric acid.

It has long been known that certain organisms such, for example, as certain species of citromyces, are capable of converting glucose in the presence of sufficient oxygen into citric acid according to the equation

$$2C_6H_{12}O_6 + 3O_2 = 2C_6H_8O_7 + 4H_2O.$$

The moulds *aspergillus niger* and *mucor piriformis* among others are also able to bring about this change, and Currie has recently adduced evidence to shew that the decomposition is an oxidation process taking place in three stages, producing first citric acid, then oxalic acid and finally carbon-dioxide. By regulating the conditions under which this process is carried out, it has been found possible to accelerate the first and retard the last two stages, and that by a judicious selection of cultures and a careful control of the conditions, the production of citric acid may be varied from little more than a trace to an amount corresponding with more than 50 per cent. of the sugar decomposed. The conditions specially favourable to the production of citric acid are a high concentration of sugar and a low concentration of nitrogen, the latter being best supplied in the form of ammonium salts. That the reaction is not by any means as simple as the above equation would make it appear, is quite certain, and the process affords a striking example of the power of the living cell to effect changes which cannot as yet be brought about by the application of any known chemical methods. At least one patent has been taken out for the production of citric acid from sugar, but whatever may be the commerical possibilities of the process it is clear that it is one which is of very great interest to the chemist from several points of view, and which is deserving of further study. In addition to citric acid, a number of other organic acids are, as is well known produced through the agency of the lower fungi, and it is quite possible that, with the extended and systematic study of the subject, the list may be considerably lengthened, and methods may be discovered for producing cheaply a number of the rarer acids for which we are at present dependent on methods involving expensive syntheses.

I may, perhaps, in passing, give two instances, namely, pyruvic acid and fumaric acid. To the first, reference has already been made in my previous lecture.

Owing largely to the researches of Fernbach and Schoen, it has been demonstrated that pyruvic acid is one of the products of alcoholic fermentation in a neutral medium, and that the acid-producing capacity of yeast is greatly increased if the fermentation is carried out in the presence of chalk.

Working in this manner, it is possible to bring about the accumulation in the fermenting liquid of a considerable amount of calcium salts of organic acids and, in the case of one organism used (a mould), the proportion of calcium pyruvate has been found to amount to no less than 75 per cent. of the weight of the sugar fermented. When employing a certain yeast in a mineral medium, the amount of calcium pyruvate amounted to 25 per cent. of the sugar used.

Owing to the instability of pyruvic acid, and the concurrent formation of other organic acids from which it is not easy to separate it, its isolation is a matter which presents some difficulty; but when the conditions necessary for its formation have been more closely studied, and better methods for its isolation have been devised, the biochemical method will probably become a convenient one for the preparation of this acid.

It may be mentioned that pyruvic acid is formed through the agency not only of yeasts and moulds, but of bacteria, and having regard to its frequent occurrence in so many different fermentation processes, there seems to be good ground for attributing to this interesting acid a considerable amount of importance from the point of view of the mechanism of the chemical reactions concerned.

The production of fumaric acid from sugar by means of the mould *Aspergillus fumaricus* has been studied by Wehmer and others. It has been found that, by the action of this mould, under suitable conditions, sugar is readily broken up, with the production chiefly of fumaric acid, together with comparatively small quantities of citric and another organic acid. The necessary conditions are: a plentiful supply of oxygen; a suitable temperature, and the presence of chalk for the purpose of neutralising the acids, as formed.

Working in this way, from 20 grammes of sugar, 33 grammes of mixed calcium salts were obtained, consisting chiefly of the sparingly soluble normal fumarate, with smaller proportions of the easily soluble acid fumarate and a little calcium citrate. The sugar used was completely fermented, from 60 to 70 per cent. of it being converted into acids.

The suggested use of bacteria on a large scale for starch liquefaction leads me now to consider one or two other manufactures in connection with which we are largely dependent upon the activities of these minute organisms, and in the first place, I should like to deal briefly with the manufacture of lactic acid, one of the most interesting chemical manufactures in which bacteria are the active agents.

Since the time of Scheele, who appears to have been the discoverer of lactic acid, it has been known that the souring of milk and other saccharine liquids when exposed to the air was due to the formation of a non-volatile organic acid, but the exciting cause of the change necessarily remained obscure until the nature of bacteria had been studied, and methods for their isolation and investigation had been devised. To Pasteur must be given the credit for showing that this was to be included among the very numerous processes which owe their origin to the activities of living micro-organisms, whilst Lister was apparently the first to prepare a pure culture of a lactic acid producing bacterium. Since that time few biochemical processes have been the subject of more numerous and more valuable investigations. To deal with these at any length would be quite outside the scope of this lecture, but it may be said at once that the number of organisms producing lactic acid either as their chief, or as one of their secondary products, is very large indeed. Thus Henneberg, who has made a very special study of this subject, divides the lactic bacteria into seven groups differing very materially both in their morphological characters and in their chemical activities. Beijerinck, perhaps wisely, rejects this and other groupings, and divides all the lactic bacteria into two large classes, the coccus forms (lacto-cocci) and the rod forms (lacto-bacilli). Speaking generally, the coccus forms occur chiefly in sour milk and cream, are most active below 30° C. and produce dextro-lactic acid, whilst the bacillus forms are mainly concerned in the souring of distillery mashes, beer wort and similar liquids, have an optimum temperature of about 40° C. and give the laevo-acid. Among the latter are the organisms which are chiefly used for the industrial production of the acid. That the transformation of the various carbohydrates is effected by means of specific enzymes has been demonstrated by Büchner and others. Thus, from one of the most active of the technical lactic bacteria *B. Delbrücki* an enzyme solution was prepared, which was found to be very active in the presence of calcium carbonate, and like the living organism itself, very sensitive to the presence of free acid. A very considerable amount of doubt exists as to the precise mechanism of this change, but that it is not as simple as the equation $C_6H_{12}O_6 = 2C_3H_6O_3$ might appear to suggest is quite certain. The problem is complicated by the existence of several isomeric lactic acids, and although the form most frequently met with is the inactive α-hydroxypropionic acid, the other isomers are formed by certain organisms and under certain conditions. With some of the organisms which have been specially isolated for industrial use, lactic acid is substantially the only product formed, but in many cases other substances are produced at the same time, among these being formic acid, acetic acid, propionic acid, butyric acid, alcohol, acetone, carbon-dioxide and hydrogen. Whether each of these substances is the result of the activity of a special enzyme co-existing in the cell with the lactic enzyme is very uncertain, but it is clear that the process is, from the chemical point of view, a very complex one. Notwithstanding this, it is capable of being effected almost quantitatively by some of these minute living organisms, and apparently with the greatest ease.

Although, as I have already stated, it has been known since the days of Scheele that lactic acid could be prepared by the fermentation of milk sugar, the production of this acid on an industrial scale dates back not more than 30 or 40 years.

In the early days, it appears to have been manufactured chiefly in this country and in America, and, so far as it is possible to ascertain, comparatively small quantities were, at that time, being produced in Germany.

Up to about 20 years ago, the Germans appear to have relied chiefly on the imported product, but with the very greatly extended use of lactic acid in connection with various industries, a number of factories were established in Germany and in other Continental countries, and, at the outbreak of war, the Germans were not only supplying their own needs, but were also considerable exporters.

It is very difficult, owing to the fact that lactic acid was not separately distinguished in the official accounts prior to the beginning of 1920, to obtain from the Customs Authorities any reliable information as to the amount imported into this country, nor is it possible to obtain from the Board of Trade any reliable information as to the amount manufactured here during recent years. I am informed, however, on good authority, that in 1912 we imported from Germany over 500 tons and in the following year this had risen to 750 tons. Owing to the war, this source was, of course, closed to English users, and in 1916, America was exporting to this country at the rate of 720 tons and Holland at the rate of about 150 tons per annum. In addition, smaller quantities were imported from one or two other countries.

In the year 1909, the Germans appear to have imported almost a negligible quantity, whilst their total exports amounted to about 1,500 tons.

It is not easy to arrive at an accurate estimate of the amount of lactic acid used here, but I think it may be taken that at the outbreak of war, it was in the neighbourhood of 1,500 tons per annum.

For the reasons stated, these numbers are given with some reserve, but they will suffice, at least, to convey an idea of the extent to which lactic acid is being employed, and there can be little doubt that, if it could be manufactured more economically and of better quality than at present, there would be a greatly increased demand, both for home consumption and for export. This brings me naturally to a point to which I wish specially to refer, namely, the fact that the manufacturers in this country have not, generally speaking, kept abreast of scientific developments, and are in many cases working under conditions which cannot fail to place them at a serious disadvantage as compared with their American and Continental competitors.

The lactic acid industry shares, in fact, with some other biochemical industries of this country, the reproach of being unprogressive, and notwithstanding the numerous scientific investigations which have been made, chiefly in Germany, it is to-day being carried on under technical conditions but little superior to those existing at the time of its introduction.

I propose, in my next lecture, to deal with some of the factors which are, in my opinion, responsible for this state of affairs. Lactic acid is one of the many commodities which, as the result of cheapened production, have assumed very considerable industrial importance, and there are good reasons to suppose that its possible uses are not by any means exhausted. The great bulk of it is at present being used in the tanning, dyeing and calico-printing industries, and smaller quantities are employed in pharmacy and in the preparation of aerated beverages. It is also used in distilleries for the purpose of souring the mash for the prevention of the development of injurious bacteria. Its effect in this case is, it may be remarked in passing, similar to that exerted in the human body as the result of the Metchnikoff Soured Milk Treatment for the prevention of auto-intoxication and intestinal putrefaction and the various diseases for which that particular condition is responsible.

The acid chiefly demanded in this country contains 50 per cent. of lactic acid by volume or 43.5 per cent. by weight, but acids of other strengths are in occasional demand.

For the various purposes above mentioned, acids of varying degrees of purity are required. Thus, for tanning it is essential that the product should be free from iron, free sulphuric acid and butyric acid, whilst the so-called "edible" acid for use in place of tartaric acid in the manufacture of effervescing beverages, and the acid required for pharmaceutical purposes must, obviously, be of a high degree of purity and particularly must contain no more than negligible traces of arsenic.

As a raw material, glucose is almost invariably employed, this being usually made in the factory from the cheapest starchy material available at the time. The actual process comprises, roughly, five steps:—

(a) The preparation of the glucose solution in a condition suitable for fermentation;

(b) The bacterial fermentation of this solution under suitable conditions in the presence of an excess of finely-divided calcium carbonate (precipitated chalk) and the production of calcium lactate;

(c) The decomposition of the resulting calcium lactate by means of sulphuric acid;

(d) The filtration and washing of the calcium sulphate formed in the preceding operation; and

(e) The concentration of the filtered lactic acid solution to the required strength.

I do not propose to describe in any detail the plant necessary for the carrying out of this process, as it is of comparatively simple character, and its nature will be obvious to all who are acquainted with ordinary industrial chemical manufacturing methods.

The stage with which I am particularly concerned this evening and on which I desire to lay special stress is the second, that is, the bacterial decomposition of the sugar.

If it were possible to carry out this stage of the process by means of a synthesized enzyme of standard activity, the matter would be relatively simple. Inasmuch, however, as the manufacturer is dependent on the living organism, and as the production of lactic acid from carbohydrates is the general property of a considerable number of widely differing bacteria, it is obviously of the highest importance to ascertain, in the first place, which particular organism is best suited for the purpose. Having made this selection, it is necessary to determine the precise conditions under which that organism functions most actively and gives the best results, both in regard to the quality and yield of the finished product.

It is, for example, necessary to know what form of commercially obtainable soluble nitrogen is best suited to the needs of the organism in question, and in what quantities it should be supplied; the temperature at which the fermentation should be conducted; what amount of aeration—if any—should be adopted, and what steps should be taken to prevent the acidity from rising beyond the point at which the activity of the organism becomes crippled.

I can say, without fear of contradiction, that much of the acid produced in this country, so far from being manufactured under such exactly determined and rigidly controlled conditions, is made in a very haphazard manner, with the result that it is of poor quality, and quite unsuitable for a highly competitive trade.

It will be obvious that the first, and by far the most serious difficulty with which the prospective manufacturer is faced is the selection of the organism to be employed; for upon this, the whole success of the process depends. Before commencing, he will be compelled to adopt one of two courses. He may, himself, take steps to isolate, in one way or another, the organism capable of giving him the results he requires, or he may endeavour to procure the necessary culture from someone else. In the first case, he must have at his command the services of someone possessed of considerable knowledge, not only of bacteriological technique, but also of the habitat of the various lactic bacteria, their life-histories, their general characters and their industrial properties. Even should he devote to this all-important preliminary work the necessary amount of time and skill, it is by no means certain that he will succeed in obtaining the organism capable of giving the best results, that is to say, the maximum yield of acid, free from objectionable by-products, in the minimum time; and, in any event, he will have to make a very careful study of his organism for the purpose of determining—as I have indicated above—the conditions under which it is capable of functioning most actively.

The alternative to this laborious and highly technical procedure is to obtain a culture of a suitable organism from some person or institution, and this is a point with which I propose to deal later.

Assuming that our manufacturer has, by one means or another obtained the right bacterium, he will still be faced with the necessity for carrying out his work in such a manner as to prevent the intrusion of other and undesirable organisms, and for providing a continuous and rigid bacteriological control.

I think I have said enough to shew that the lactic acid industry in this country is susceptible of considerable development, and that such development depends on the ability to produce the acid in a reasonable

state of purity (having regard to the purposes for which it is to be employed) and at a competitive price.

Before this state of affairs is realised much progress will have to be made, and the haphazard and rule-of-thumb procedure at present so frequently followed will have to give place to methods much more closely in accordance with the latest teachings of science.

If the conditions of the lactic acid industry are very far from being satisfactory, the conditions in the allied industry concerned with the manufacture of normal (fermentation) butyric acid are infinitely worse. As in the case of lactic acid, the number of bacteria producing butyric acid, either directly or indirectly is very large, and there is much less uniformity of opinion as to the precise organism (or, indeed, as to the class of organisms) best suited for industrial purposes. It was formerly supposed that the production of butyric acid from glucose takes place according to the equation:

$$C_6H_{12}O_6 = C_4H_8O_2 + 2CO_2 + 2H_2$$

but there appears to be some evidence that the gases formed in the process of fermentation are the result of secondary reactions.

If we have left behind the days when it was customary to start the fermentation by the introduction of a small amount of decomposing meat or cheese, we are very far from having arrived at a knowledge of the best and most economical conditions for the biochemical production of this acid.

So far as my experience has gone, manufacturers have rarely any precise knowledge of the nature of the organism they are using, or of the best conditions for its development. In consequence, the yields of acid are often low and the quality poor.

There seems to be very little doubt that, as in the case of lactic acid, the active principle is an enzyme, and it would appear, according to Stoklasa and his co-workers, that this enzyme usually occurs in bacteria, together with the enzyme producing lactic acid.

I should like now, with your permission, to refer to another important and ancient biochemical industry, namely, the manufacture of vinegar.

Of all the biochemical industries, that of vinegar making is one of the oldest, being almost certainly more or less contemporaneous with the discovery of wine, which was, doubtless, its first source. The industry appears to have established itself in France at a very early date, and long before any factory had been erected in England, wine-vinegar was imported from that country. The date at which the first vinegar factory was erected in this country is uncertain, but the manufacture was certainly being carried on in the early part of the seventeenth century, and in the reign of Charles II. its taxation was provided for in the Revenue Act of 1673.

My reason for this brief incursion into the historical side of the subject will be apparent a little later. Essentially the manufacture of vinegar consists of the oxidation of alcohol to acetic acid through the agency of certain micro-organisms, and for its economical production almost any wholesome and convenient alcoholic liquid will serve as raw material. It will be clear from this that I exclude the factitious product made by diluting and colouring ordinary acetic acid.

Inasmuch as the production of vinegar is only a stage—and one sometimes unintentionally traversed — beyond the manufacture of alcoholic beverages, it follows that the nature of the alcoholic liquid employed in its manufacture, in any country, will usually be the staple alcoholic beverage of that country. Thus, in wine drinking countries, such as France and Italy, wine is the usual raw material, whilst in beer drinking countries, the necessary alcohol is obtained from the materials usually employed in the brewing of beer, such as malt, raw grain of various kinds, and sugar. As an indication of the various materials from which vinegar is made, the following brief extract from a recent circular of the United States Department of Agriculture may be of interest:—

1. "*Vinegar, Cider Vinegar, Apple Vinegar* "is the product of the alcoholic and "subsequent acetous fermentation of "the juice of apples."

   This is the chief vinegar of the United States.

2. "*Wine Vinegar, Grape Vinegar* is the "product made by the alcoholic and "subsequent acetous fermentation "of the juice of grapes."

3. "*Malt Vinegar* is the product made by "the alcoholic and subsequent acetous "fermentation, without distillation, "of an infusion of barley, malt or "cereals, whose starch has been con-"verted by malt."

4. "*Sugar Vinegar* is the product made by "the alcoholic and acetous fermentation of solutions of sugar, syrup, "molasses or refiners' 'Syrup.' "
5. "*Glucose Vinegar*" is the product made "by the alcoholic and subsequent "acetous fermentation of solutions "of starch, sugar or glucose."
6. "*Spirit Vinegar, Distilled Vinegar, Grain* "*Vinegar* is the product made by the "acetous fermentation of dilute dis-"tilled alcohol."

It will be seen, therefore, that as a source of alcohol, a large variety of sugar-containing or sugar-producing materials are available, the procedure common to all the processes being the biochemical conversion of the alcohol into acetic acid, together with small quantities of other secondary products which give to the resulting vinegars their characteristic flavours. The progress made in the first, or purely chemical stage of the process—that is, the production of the alcoholic liquid which is to be acetified—has, of course, been identical with that of the allied fermentation industries, and so far as the preparation of the alcoholic wash is concerned, the vinegar industry may be said to be on a fairly sound and satisfactory basis. On the biological side, the position is rather different.

The alcoholic wash having been prepared by the fermentation of any of the above saccharine materials, passes to the acetifier. This is a conical wooden vessel, having a capacity of several thousand gallons.

The upper part is filled with twigs, wooden shavings or basket work, which offer a large surface for the lodgment, growth and action of the acetifying organism.

The alcoholic wash is contained in the lower part of the vessel which is separated from the upper by a false bottom. For its acetification, it is continuously pumped to a smaller vessel, feeding a revolving sparge, which delivers it in the form of a spray over the twigs, shavings or basket work above referred to.

When working in this manner, the wash trickles over a very large surface, coated with the active organisms and in the presence of a constant supply of air. This very necessary aeration is usually effected by having a number of holes bored through the side of the acetifier, just below the false bottom.

The amount of air supplied in this manner can, of course, be easily regulated, and a constant current is maintained owing to the heat generated in the upper part of the vessel by the oxidation process.

The temperature at which the process is conducted varies somewhat considerably, but in this country it may be taken that the range is usually from 100°F. to 110°F. On the Continent, on the other hand, the temperatures customarily adopted are considerably lower, being usually in the neighbourhood of 90°F.

I need not refer, in any greater detail, to the plant employed, nor do I propose to deal with the subsequent processes of filtration, clarification, storage and (occasionally) sterilisation to which the vinegar is subjected before being sent out into the trade. Suffice it to say that working practice varies somewhat considerably in different factories ; but the above may be regarded as indicating substantially the general nature of the acetification process almost invariably adopted.

It will be gathered that the acetifying plant is of very simple, not to say, crude construction and, as might well be supposed, it is apt to be inefficient and wasteful.

Remembering that the temperature of the acetifying wash is well over 100°F., that comparatively large volumes of air are being passed through during the whole of the process (which may take anything from a week to a fortnight), and that alcohol, aldehyde and acetic acid are all very volatile substances, it is not surprising that the yields obtained in practice should fall very far short of those demanded by theory. By the use of a condensing pipe and washer, a good deal may be done to reduce the loss, but a deficit of from 10 to 20 per cent. is very usual, and much greater losses are not entirely unknown.

In addition to the above sources of loss, it has to be borne in mind that the acetic acid bacteria employed, or other organisms which accidentally gain admission, are capable of oxidising and so destroying the acetic acid formed.

The conversion of alcohol into acetic acid is effected by a considerable number of bacteria, differing very widely in their morphological and other characters.

In 1878, this subject was investigated by Hansen, who isolated and studied three distinct organisms, to which he assigned the names :—

Bacterium Aceti, *Bacterium Pasteurianum* and *Bacterium Kützingianum* respectively.

Later, Adrian Brown called attention to an organism producing acetic acid, to which he gave the name of *Bacillus xylinus*, an organism which very rapidly forms a thick leathery skin.

Frequent occurrence of this zoogloeal condition is very characteristic of the acetic acid bacteria and, in practice, often becomes a source of difficulty.

To what extent the numerous acetifying bacteria represent definite species is uncertain. Some of the organisms described in literature may well prove to be merely involution forms of others, produced by variations in the culture conditions. Even when allowance is made for this possibility, there can be no doubt that the number of organisms whose chief chemical function is that of converting alcohol into acetic acid is considerable, and probably others remain to be discovered.

Notwithstanding the great advances made in many directions in industrial zymotechnology as the result of improved methods of bacteriological technique, and in consequence of the greater amount of attention devoted, during recent years, to this important subject, the position of the vinegar industry has remained almost stationary.

Apart from the crude apparatus they employ, vinegar makers rarely, if ever, know anything of the precise character of the all-important organism (or organisms) they are using, nor, except in a very rough way, do they know the most suitable conditions for obtaining—through its agency—the maximum yield of acid.

The converting material employed is, as my own experience has shewn, usually a mixture of various organisms, of which one is, of course, predominant. Even assuming that this predominant organism is the one best suited for the class of vinegar required in any particular factory, nothing is known as to the injurious effect which the other organisms present may exert, either during the process of manufacture, or even upon the stability and character of the finished product.

It has been shewn that the different species of acetic acid organisms are capable of producing vinegars having different aromas and flavours, and there can be little doubt that, by proper selection, it would be possible to obtain pure cultures for acetification which would have the effect of increasing very considerably the yield of acid, and which might be found to produce vinegars having any desired flavour and aroma.

Thus Villon—working in this direction—succeeded, more than 20 years ago, in isolating from acid wine three distinct varieties of the *Bacterium aceti*, which were found to give very different results in practice.

One of these (to which he refers as "No. 1") produced a vinegar of very high quality and of marked stability.

"No. 2" gave a product of average keeping properties and appeared to be identical with the organism chiefly employed for acetification in French factories.

"No. 3" produced a turbid vinegar having an inferior flavour and marked instability.

Villon recommended, as the outcome of these experiments, the use, in practice, of pure cultures of the "No. 1" organism; but he pointed out that it was slower in action than either of the other two, and also tended to become exhausted more quickly.

I merely refer to this to show that, as in the manufacture of beer or of wine, the precise species or variety of organism used has a marked effect upon the flavour and other commercial properties of the finished product, and that there is abundant scope for further detailed and systematic investigation.

Quite apart from the character of the finished product, there is much need for such investigation with the object of ascertaining the particular species or variety of bacterium best adapted for working with different types of acetifiers. Thus, the *Bacillus xylinus* of Adrian Brown—which possesses the characteristic of forming very thick and tough skins—is particularly objectionable in some forms of acetifier, and it may be that if steps were taken for its exclusion, there would be much less difficulty than is at present sometimes experienced in connection with the choking of these vessels.

It may be said that vinegar is mainly used as a condiment, that the production of artificial, or synthetic, vinegar is more rational and more economical, and that the industry—as measured by its total output, possibly 15 million gallons per annum—is not one of great national importance.

The reply to such objections would, of course, be that fermentation vinegar, when properly prepared, has condimental qualities which artificial vinegar (diluted acetic

acid), even when toned up with a little fermented vinegar, or with various ethereal flavourings, does not possess, and that the comparative smallness of the industry is no reason why it should not be carried out in the most efficient and economical manner possible, on the principle that if a thing is worth doing at all, it is worth doing well.

In support of my plea for more systematic biological investigation in connection with the manufacture of vinegar, the following views of three persons of different nationalities, who can claim to speak with authority, may be given.

Mr. C. A. Mitchell, whose experience of vinegar-making is very large, says, in speaking of the flavour of vinegar:—

"It is to be feared that too little stress "is laid upon the aroma of the vinegar "brewed in England to make the use "of pure cultures of bacteria appre- "ciated from this point of view. On "the other hand, it is possible that by "the use of cultures of special species "the loss of acid during acetification "might be materially reduced." (Vinegar: its manufacture and examination, 1916).

Lafar, writing in 1898, says:—

"Up to the present no precise in- "vestigations on the bacteria acting "in this branch of industry have been "made public. This highly necessitous "industry has, more perhaps than any "other, to struggle against a variety "of difficulties; the actual losses of "alcohol are enormous, and no one is "able to offer any reliable explanation "of their cause. The introduction and "intelligent use of suitable pure culture "ferments would be a great boon. How "much still remains to be done and "ascertained in this instance can be "estimated by a comparative glance at "the conduct of fermentation in the "operation of brewing."

M. Alilaire, in a contribution to the "Annales de la Brasserie et de la Distillerie" for May, 1920, says:—

"Il est très rare depuis quelques années "de trouver dans les publications "scientifiques ou industrielles des articles "sur ce sujet (*i.e.*, vinegar), et il semble "que depuis Pasteur aucun progrès réel "n'a été fait dans cette industrie. . .

"La fabrication du vinaigre de vin "est restée à peu de chose près ce qu'elle "était en 1868, époque à laquelle Pasteur "a publié ses travaux. . . .

"Quels progrès a-t-on faits depuis "cette époque? . . A combien de "millions pour le pays peut-on évaluer "les résultats de ses recherches" (de "Pasteur) "en vinification, dans la "brasserie et la distillerie? Les levures "sélectionnées! Les moûts stérilisés! "Les ferments purs dans les autres in- "dustries! Des laboratoires se sont "montés, des chimistes se sont spécialisés "et ont continué l'œuvre qu'un seul homme "était incapable de conduire jusqu'au "bout. Au milieu de ces progrès, quel a "été l'effort des vinaigriers? Quels sont "les ferments employés par eux? où "sont-ils sélectionnés? dans quels la- "boratoires fait-on les recherches pour "améliorer la fabrication? quelles sont "les publications qui parlent des progrés "réalisés? à quel chiffre d'exportation "arrive-t-on pour ce produit bien français "qui devrait être consommé dans le "monde entier s'il avait les qualités "desirées? Toutes ces questions restent "sans réponse. Pendant combien de "temps encore verra-t-on cette industrie "travailler par routine et par ignorance "dans des conditions désastreuses? "L'avenir seul pourra nous l'apprendre."

I do not desire unnecessarily to labour this point, but the above quotations will I think, suffice to show how much remains to be done to put this ancient and interesting industry on a really satisfactory biochemical basis.

COTTON IN AMERICA.

The area planted with cotton in the United States in 1921 is reported by the "Financial and Commercial Chronicle" to be only 27,875,750 acres against 37,043,000 acres in 1920. This represents a drop of 24.75 per cent., and is the smallest acreage planted since the season of 1902-3. The condition of the plant, "is, with the exception of 1920, the poorest on record for the time of the year, the average status of the crop for the whole belt on 25th May having been reported as 66 per cent. of a normal, against 62.4 on the same date last year. . . . and a ten-year average of 76.7." Since that date, weather conditions have been, on the whole, more favourable, but this season there has been "a noteworthy decrease in the use of commercial fertilisers."

The commercial crop, actual growth, including linters, was 11,920,625 bales in 1919-20, when 36,166,000 acres were planted, and the carry-over at the end of the 1920-1 season is expected to be between 10½ and 11 million bales. Accord-

to the Department of Agriculture the average price received by producers for cotton was 10.3 cents per lb. in 1911-12, 11.6 cents in 1912-13, 12.6 cents in 1913-14, and 35.3 cents in 1919-20; in July, 1920, it averaged 37.4 cents, but in April and May it was only 9.4 cents. Mildand Upland cotton in New York averaged 10.83 cents per lb. in 1911-12, 12.30 cents in 1912-13, 13.30 cents in 1913-14, and 38.25 cents in 1919-20; on 22nd July, 1920, it reached 43.75 cents, but on 1st March, 1921, it had fallen to 11.65 cents; on 1st June it recovered to 12.90 cents.

CULTIVATION OF SISAL IN JAVA.

The cultivation of sisal in Java is comparatively simple. It is generally planted on land that is not suited to rubber, in which coffee or some other crop has previously been planted, or on land not fit for any other culture. In some districts "lamtoro" is planted between the rows. This plant provides the additional nitrogen that the sisal requires. Every third crop is planted in the soil on which the "lamtoro" was previously grown.

Young plants are raised in nurseries, where they remain until they are one and one-half to two years old, when they are transferred to the field, usually from October to January. Planting is done in rows 12 feet apart, the distance between plants being 3 feet. The soil is kept as free from weeds as possible (within a reasonable cost) during the first three years, and during the same period the soil between the "lamtoro" and sisal is deeply hoed. The plants are constantly casting leaves throughout their growth, and during the growing period these are cut away and hoed under.

When the plants are two years old the mature leaves are about 24 inches long. Harvesting then begins and continues until the plant blossoms, which occurs when it is six years old. The leaves are cut by the natives with the "arit," a knife universally used, and carried to a light railway, where they are loaded on cars and conveyed to the factory.

For preparing the fibre several makes of machines are in use. The heavier work of feeding and carrying is done by men and the lighter work by women. From the machines the fibre is taken to the drying racks in a field reserved for that purpose, where it is exposed to the sun from one to two days, after which it is sorted by women and baled in hand presses.

The following figures of the production of sisal were furnished to the United States Trade Commissioner in the Dutch East Indies by an estate in East Java, which may be said to be fairly representative of those of other estates:—

When the plant is two to three years old (first harvest) the yield of leaves is 5 piculs to the buow (picul = 136 pounds; buow = 1.75 acres); three to four years old, 20 piculs; four to five years, 40 piculs; and five to six years, 25 piculs. In the first six years, therefore, the total production of leaves is 90 piculs per buow, an average of 15 piculs per year of growth. The sisal plant cut during the first harvest yields about 2 per cent. of fibre; the average for the succeeding three harvests is 3½ per cent. of fibre.

The area planted to sisal in Java in 1919 was 23,089 acres.

CANADIAN FLAX FIBRE TWINE.

The Canadian Government has for some time been studying the possibilities of recovering and utilizing straw from flax grown for seed. In its more recent work it has sought to ascertain the value of the conclusions reached in previous investigations to discover some means of separating the flax straw without materially injuring the fibre and to obtain figures of the cost of converting the fibre into cordage, felt, and other products. The investigation included a comparison between matured straw and straw frozen before maturity. The conclusions drawn in regard to these qualities, according to a report by the U.S. Consul at Kingston (Ontario) were that grain straw could not be decorticated, and that fully matured straw was slightly better than almost mature frozen straw for fibre production.

The fibre ultimately obtained was chemically treated in specially prepared vats by a fermentation process which requires only a few hours. After being thus treated the fibre was shipped to a cordage factory where it was made into binder twine and baled. The twine has not been tested sufficiently under field conditions to justify a definite pronouncement of its value. Commercial twine and rope were also made, but definite conclusions regarding their value have likewise not been established. Waste material was found useful for felting purposes, and when mixed with 20 per cent. of animal hair it could be used for insulating.

In these experiments 77 tons of flax straw, taken from 173 acres, gave 17½ tons of raw fibre, which, when further refined, produced 347 bales of 90 pounds each of treated fibre. From 123 of these bales there was manufactured 5,987 pounds of cordage. With regard to the cost of production, it has been worked out that 1 ton of straw of seed-producing flax will give 249 pounds of binder twine and 142 pounds of felting material, and that the binder twine was manufactured by the process followed at a cost of 13.54 cents per pound, and the commercial twine for 20.54 cents per pound.

THE GERMAN PRISMATIC FIELD-GLASS INDUSTRY.

In the German prismatic field-glass (prismenfeldstecher) industry is included not only the manufacture of prismatic field glasses but of

Galilean telescopes (Galileische ferngläser), observatory telescopes (standfernrohre), and the like. The manufacture of these products is practically confined to 11 large concerns. The principal centres of production are Rathenow, Berlin, Wetzlar, Cassel, Goettingen, Munich, and Brunswick.

It appears from a report by the representative at Berlin of the United States Department of Commerce, that the retail price of prismatic field glasses of German manufacture is fixed by a special committee of the joint association of manufacturers of and wholesale dealers in optical articles. The prevailing slackness in business in Germany, due to the public's disinclination to buy, has had its effect upon this industry.

Before the war Germany's principal market for prismatic field glasses was abroad. The products of this class of German manufacture enjoyed unusual popularity in the United States and Canada, to which this industry sold about half of its output. Other important markets were Britain, France, Italy, Austria-Hungary, Switzerland, Spain, Russia, and the Balkan States. A not inconsiderable trade was also being built up in South America and other overseas markets. During the war prismatic field glasses could only be manufactured in Germany on a limited scale. The military authorities seized practically all the necessary raw material and supplied the factories with only such quantities as were necessary for the manufacture of army models. About the only export of prismatic field glasses to speak of was to Austria-Hungary.

At the conclusion of the war the manufacture of prismatic field glasses was resumed. Up to the spring of 1920 a big business was done, the manufacturers being unable to supply the demand. The greater part of these glasses was sold in Germany and the remainder in the Scandinavian countries, Holland, Italy, Spain, and Switzerland. The German manufacturers in this industry are in process of re-establishing connections in their former foreign markets, and are hoping to see their export trade soon again in full swing.

THE WORLD'S TRADE IN CATTLE AND ANIMAL PRODUCTS.

The upheaval of International trade in cattle and its derivatives during the war has recently been demonstrated in the publication of the statistical office of the International Institute of Agriculture, namely, the *Commerce International du Bétail et de ses dérivés*, in which all the countries of the world are included.

This work includes the relative data of imports and exports for the five years 1915 to 1919 for each species of live stock, and for meat, fats, milk, butter, cheese, leather, skins and wool.

From the closely printed tables of figures, which cover about 150 pages, the most radical transformations in the international trade are brought into evidence, as a result of the exceptional conditions prevailing at the time. The number of horses exported from the United States during 1915 amounted to about 450,000 as compared with the 30,000 exported before the war. Trade in butchers' animals has decreased perceptibly, while, on the contrary, trade in frozen meats has been much more developed. The Argentine, Brazil, Canada, the Union of South Africa, and New Zealand show a substantial increase in their exports of beef; Uruguay and New Zealand for mutton, and Canada and the United States for pork. There is also a very considerable increase in the exportation of animal fats, lard and bacon, especially from the Argentine, Brazil, the United States, China and New Zealand.

The exports of condensed milk from the United States have made a tenfold increase in five years, passing from 35,000 metric tons in 1915 to about 390,000 in 1919. The butter exports from North and South America are continually on the increase, but fail to compensate for the greatly diminished exports of Denmark, Holland, Russia and Sweden. Cheese exports from European countries have most perceptibly decreased, especially those of Holland, Switzerland, Italy and France.

International trade in leather is on the increase.

A great falling off in wool exports was noticed during the years 1916, 1917 and 1918, which was followed by a noteworthy recuperation in 1919, especially with regard to Australian and South African products.

GENERAL NOTES.

Victoria and Albert Museum.—Wall Papers and Posters.—An exhibition of wall-papers and posters is now open in rooms 95-99. Of special note among the wall-papers is a French set, of the Empire Period, of twenty-five sheets, representing a continuous picture of a hunting scene, making a run of 44 feet for the complete papering of a small room. This was given by Sir William Ingram, Bart., to whose generosity is also owing a series of nine panels of a painted Chinese wall-paper. There are other examples of Chinese papers, and from these one passes to examples illustrating the history of British papers from the early 16th century to the designs of William Morris, Walter Crane and other modern artists. The posters, which represent a selection only from the large collections now in the Museum, are arranged to show the work of different countries, Great Britain, the United States, France, Germany, etc. The British section contains a very early example of a poster designed by Walter Crane

in 1888; notable work by the "Beggarstaff Brothers," and Aubrey Beardsley, who, at the start, set a very high standard for English Poster Art; and groups of work by living artists such as Frank Brangwyn and Spencer Pryse. A recent large acquisition has enabled the Museum to show a remarkable series of early French posters by well-known artists, such as Chéret, Steinlen, Toulouse-Lautrec, Grasset, Mucha, etc. In every country posters played a very prominent part in the history of the War, and were used for every form of propaganda. British and French War posters are well represented, among the latter being famous works by Steinlen, Faivre, Poulbot, Willette, Roll and others; while special interest attaches to chosen examples of German posters, which hold their own by sheer force and efficiency.

THE DWARF-PALM.—A monograph of the dwarf-palm, or "mazri" (*Nannorhops Ritchieana*) by Ram Sarup Dutt, printed at the Addison Press, Madras, contains a great deal of useful information about this tree. It grows wild in the Kobat District of the North-West Province, where it plays an important part in the economic life of the people. The leaves produce a good fibre suitable for use in sandals, ropes, matting, baskets, punkahs, brooms, etc.; the dry leaves make good fuel, or, rather, kindling, and the fruit is eaten. In addition to the local production, which is valued at about five lakhs of rupees, *mazri* articles of the aggregate value of Rs. 1,22,203 were imported in 1915-16 from the Kurram Valley, Tirah and Kabul. The monograph gives an account of the present condition of the trade, and also suggestions for the commercial exploitation of *mazri* on a wider basis. The author suggests the use of *mazri* leaves in the manufacture of paper, pasteboard, brushes, and for such household articles as chairs, suit cases, hat boxes, tiffin baskets, door mats, etc. In view of the backward conditions of the Kobat District, where no regular attempt is made to cultivate the tree, and the manufacture of fibre articles is carried on in a hap-hazard manner, he thinks that the Government should pioneer the industry, and that experiments should be made to see if *mazri* can be cultivated as a field crop. He believes that there would be no scarcity of labour, as the discharged Sepoys in the Kobat District will be available in sufficient numbers.

PERISHING OF PAPER IN INDIA. — The Journal of the Indian Institute of Science contains a report on "The Perishing of Paper in Indian Libraries." In their main conclusions the investigators (Mr. J. J. Sudborough and Miss M. M. Mehta), do not differ greatly from the report of the Committee on the Deterioration of Paper in Europe, published by the Royal Society of Arts in 1898. The type of paper found to be most resistant to "perishing" in India is a rag-paper, the fibres of which have not been weakened in the process of manufacture. Treatment injurious to the fibre is prolonged digestion with alkali, over bleaching, non-removal of the last trace of bleach by antichlor, and imperfect washing that leaves traces of acid in the paper, while rosin and filling material should not exceed a small fixed percentage. It is recommended that all books and documents of permanent value should be removed to libraries in hill stations with temperate climates, or placed in special buildings in which complete air control can be maintained.

SUGAR INDUSTRY IN THE FEDERATED MALAY STATES. — The Government of the Federated Malay States on January 6th, 1921, made official announcement of liberal inducements offered for the cultivation of cane sugar. The offer includes a lease of land for a period of 14 years, with renewals for a similar period for every acre cultivated. For the first three years the rent will be free and thereafter at the rate of one dollar (Straits currency) per acre. It is provided that sugar only may be cultivated, but annual food crops may be grown as rotation crops. No export duty will be imposed during the years 1922-1926, and for the succeeding five years the duty is not to exceed 2½ per cent. ad valorem. It is further provided that a factory of sufficient capacity to deal with the crop raised on the area leased is to be erected within two years. In calling attention to this official announcement, the United States Consul at Penang points out that some years ago the sugar industry prospered in the Provinces of Wellesley and Perak. A fall in the price of sugar made it more profitable to turn to the production of rubber, and the sugar industry practically disappeared from the Malay Peninsula. Now rubber is passing through a slump and it is proposed to revive the production of sugar. The prosperity of the Malay Peninsula depends almost entirely on the exportation of rubber and tin, and it is felt that this does not give a sufficient variety of products, in view of the fact that Malaya has great need of food crops.

MAGNESITE IN MANCHURIA. — Japanese mining engineers report that there are extensive and well-proved deposits of magnesite in Manchuria which are of great potential value. The magnesite, according to *The Engineer*, is, in fact, too pure for making into the usual brick form without the admixture of 7 to 8 per cent. of iron. The larger part of the deposits is owned by Japanese, but considerable areas are in Chinese hands. Occurring with the magnesite are important talc deposits, said to equal the best French material. The known deposits of these materials are all within from 3 to 10 miles of the South Manchuria railway.

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURE.

MICRO-ORGANISMS AND SOME OF THEIR INDUSTRIAL USES.

By A. Chaston Chapman, F.I.C., F.R.S.

Lecture III.—*Delivered December 20th, 1920.*

The latter part of my last lecture was devoted to a consideration of a very ancient biochemical process and one in which the chemical change involved was of a comparatively simple character.

We know very little of the precise methods by which enzymes act, but there is no reason to suppose that the bacterial conversion of alcohol into acetic acid is more complex than the conversion by inorganic catalysts, such as platinum black.

I propose to commence my lecture, this evening, with the consideration of a biochemical process of very recent introduction, and one in which the chemical changes involved are, apparently, of a complex character. I refer to the production of butyl alcohol and acetone by a fermentation process.

For a considerable time, it had been known that butyl alcohol and other higher alcohols can be produced from carbohydrate materials through the agency of bacteria. The first observation that, in some of these fermentation processes, a certain amount of acetone was simultaneously produced appears to have been made by Schardinger, in 1905, who described the bacillus, to which he gave the name *Bacillus macerans.* To Fernbach, however, belongs the credit of having been the first to isolate an organism capable of producing substantial quantities of butyl alcohol and acetone from starchy materials. As is well known, this process was worked out on a commercial scale in this country, the main object at the time being to produce butyl alcohol in quantity, as a starting point in the manufacture of synthetic rubber.

Subsequently, other patents were taken out and with these the names of Weizmann, Bayer and Co., and Northrup are associated.

As many who are present this evening are well aware, this process has been the subject of a good deal of rather heated controversy, and I have no desire to do more than say that it is very generally admitted that to Fernbach belongs the credit of having discovered, in or about 1910, the process by which acetone and butyl alcohol are simultaneously formed from starchy materials, and that these included (according to Fernbach's own statement) both maize and potatoes.

It is scarcely necessary for me to point out that acetone is, ordinarily, manufactured from the acetic acid derived from the destructive distillation of wood and that, prior to the War, the great bulk of this material used in this country came from the United States or from Austria. Owing to the enormously increased demand, during the War, for acetone—in connection with the manufacture of cordite and also, later on, for aeroplane dope—and to the cutting off of Austrian supplies, the need for increased production of acetone became a matter of the greatest national importance.

Among other processes which were submitted to investigation was the biochemical process to which I have already referred.

Without going into details, it may be said, quite generally, that the results obtained by the working of this process were such as to show that acetone could be successfully produced on a large scale, and that under certain circumstances the biochemical method constitutes a very valuable auxiliary process.

Essentially, this method consists in the bacterial fermentation of a starchy mash under strictly aseptic conditions and the separation of the two main liquid products, namely butyl alcohol and acetone, by fractional distillation.

The method of working adopted during the War has been dealt with in a very interesting paper by Mr. Amos Gill, published in the Journal of the Society of Chemical Industry, and to this I am indebted for much information in regard to working procedure.

As in the great majority of biochemical processes, the first step is to secure a pure laboratory culture of the required organism. When this culture is found to be in a sufficiently vigorous condition, it may be used for the inoculation, in one or more stages, of a larger quantity of material in order to obtain, ultimately, a sufficient quantity for the pitching of a large fermenting tank.

Some authorities, however (including Fernbach), object to this progressive mode of working and favour the elimination of the seed tank and the working up of a sufficient quantity of laboratory culture for the full-sized fermentation.

Maize was the material chiefly used during the war, and considerable importance attaches, not merely to the character of the maize used, but to the manner in which it is milled and cooked.

The acetone bacillus appears to require its nitrogen in the form of protein, and consequently the presence of the outer portions of the maize is necessary for active fermentations. The maize having been carefully ground to the required degree of fineness, is transferred to a cooker, which serves the double purpose of cooking (that is, rendering the starch soluble) and of sterilization.

The vessels employed at the King's Lynn Factory were of 3 thousand gallons' capacity, but, according to a statement contained in Sir Frederic Nathan's very interesting communication to the Society of Chemical Industry Conference, in July, 1919, there were in the British Acetone's Factory, in Toronto, in 1918, no less than 22 fermenting vessels, each having a capacity of 30 thousand gallons, and a total output of nearly 200 long tons a month. The fermentation, under normal circumstances, is complete in 30 to 36 hours, but in the Canadian Factory, this appears to have been shortened, in some cases, to as little as 24 hours. The completion of the fermentation process is judged by the cessation of the evolution of gas.

In the English factory, the starchy mash was made of such a strength that it contained about 6 per cent. of maize, but the Canadian workers appear to have employed stronger mashes than this and to have obtained—according to Colonel Gooderham—their best results at a concentration of about 10 per cent.

At its period of greatest vigour, gas is produced, during this process, at the rate of about 800 cubic feet per hour, or a total volume of about 9 thousand cubic feet from a three-thousand gallon fermentation.

When the fermentation is complete, the liquid is transferred to a storage tank and from this, is fed into a double-column continuous still.

It is not my object to refer, at any length, to working details, as these will be found very fully described in the Paper by Mr. Gill, to which I have already referred.

The following may be regarded as roughly indicating the course taken by a normal fermentation :—

The initial acidity of the mash (which is, of course, very small) gradually increases until it reaches a maximum at the end of from 12 to 18 hours, the precise length of time taken to reach this point depending on several factors, such as the amount of pitching culture added, temperature, etc. After this point is reached, the rate of production of acetone, butyl alcohol, carbon dioxide and hydrogen increases very considerably, whilst the acidity falls to a fairly constant value, which may be, roughly, taken as being from one-half to one-third of the maximum. The rate at which gases are evolved increases steadily for some hours with the increasing acidity, but when a certain point is reached, the acidity is gradually reduced, whilst the rate of gas-evolution rapidly rises to a maximum and then falls equally rapidly, until the end of the fermentation. The amount of acidity left in the fermented mash is, as a rule, greater than that present in the original mash when inoculated.

The fermenting mash appears to contain varying proportions of acetic acid and butyric acid, the ratio of the latter to the former increasing as the total acidity increases and reaching a maximum at the point of greatest acidity. The evolved gas consists of a mixture of hydrogen and

carbon dioxide, in proportions varying from 3 to 1 at the beginning, to 2 to 3 during the latter part of the fermentation. Probably the higher percentage of hydrogen in the gas evolved during the earlier stages of the fermentation is due, in part, to the solubility of a proportion of the carbon dioxide. In addition to acetic and butyric acids, there is evidence of the presence of a third and less volatile acid which has not as yet been identified.

This series of reactions has been made the subject of a very interesting study by Reilly, Hickinbottom, Henley and Thaysen (Biochm. Journ. 1920. 14. Page 229). Their results indicate that the starch undergoes hydrolysis prior to its decomposition as above described, and consequently, the total weight of end products is in excess of the actual weight of starch fermented. This is shewn clearly in the following table taken from the paper above referred to:—

TABLE.

From Observations made at the Royal Naval Cordite Factory, Holton Heath.

1,000 lb. maize containing 650 lb. starch. Volume of mash (6.5 % maize) = 1540 gallons.

			lb.	Carbon content.
650 lb. starch yield	3410 cu. ft. of CO_2 evolved—measured at 27° and 760 mm.	=	70 acetone 163 n-butyl alcohol 390 CO_2 evolved	43.5 105.7 106.3
1 vol. of mash dissolves 0.555 vol. CO_2 at 38°	135 cu. ft. CO_2 in solution at 0° and 760 mm.	=	17 CO_2 in solution	4.6
	2090 cu. ft. H_2 at 27° and 760 mm.	=	11 H_2	—
Total gas evolved (Composition of gas assumed to be constant throughout the fermentation).	= 5.5 cu. ft. at 27° and 760 mm. of mixed gas per 1 lb. of maize fermented			
	Residual acidity*	=	12.0 containing	5.7
			663.0	265.8

Theoretically 650 lb. of starch is equivalent to 722 of hexose.
The carbon content of these amounts to 288.8 lb.

* The residual acidity is taken as acetic acid 56.5 % by weight, and butyric acid 43.5 % by weight. The non-volatile portion is recorded as butyric acid for the purpose of calculation.

Calculated as Percentage of Starch Fermented.

100 grm. starch gives 111.1 grm. hexose and contains 44.4 grm. carbon.

	grm.		Carbon.
100 grm. starch gives	10.77	acetone	6.68 grm.
,, ,, ,,	25.07	n-butyl alcohol	16.21
,, ,, ,,	62.61	carbon dioxide	17.07
,, ,, ,,	1.60	hydrogen	—
,, ,, ,,	1.80	residual acidity	0.85
	101.85		40.81

It should be mentioned that a small proportion of ethyl alcohol is usually obtained in this process, but there is some considerable doubt as to its source and as to whether it is to be regarded as a normal product of the main fermentation change.

The proportions in which the various end-products occur and their quantitative relation to the starch fermented, as shown in the above statement, may be represented approximately by the following two equations, the first representing, of course, the hydrolysis of the starch and its conversion into a hexose, and the second, the decomposition of the hexose into the various products above referred to :—

(*i.*) $3\ C_6H_{10}O_5 + 3\ H_2O = 3\ C_6H_{12}O_6$.

(*ii.*) $3\ C_6H_{12}O_6 = 2\ C_4H_{10}O + C_3H_6O + 7\ CO_2 + 4\ H_2 + H_2O$.

Reilly and his colleagues provisionally incline to the view that the mechanism of the changes involved in this process may be similar to that suggested some years ago by Büchner and Meisenheimer, to explain the formation of butyric acid and butyl alcohol from glucose by the *Bacillus butylicus.* According to this view, it is supposed that lactic acid is first formed and that this is then converted into acetaldehyde and formic acid. The acetaldehyde condenses into aldol, and from this compound butyl alcohol is obtained by reduction, and butyric acid by a process of molecular re-arrangement.

This may be represented by the following equations :—

(*i.*) $2\ CH_3.CHO = CH_3.CH(OH).CH_2.CHO$.

(*ii.*) $CH_3.CH(OH).CH_2.CHO + 2H_2 = CH_3.CH_2.CH_2.CH_2.OH + H_2O$.

(*iii.*) $CH_3.CH(OH).CH_2.CHO \rightarrow CH_3.CH_2.CH_2.COOH$.

This explanation involves the assumption that the Carbohydrate is, in the first instance, converted into an intermediate substance (? lactic acid), having half the molecular weight of the hexose, and that this then gives rise to formic acid and acetaldehyde. The formic acid would then be converted into carbon dioxide and hydrogen, whilst the acetaldehyde would yield butyl alcohol and butyric acid.

This may be represented in part by the following scheme :—

$3\ C_6H_{10}O_5 + 3\ H_2O = 3\ C_6H_{12}O_6$

(Intermediate substance) $6\ (C_3H_6O_3)$

$6\ H.COOH$ $\qquad$ $6\ CH_3.CHO$

The above mentioned authors point out that, although they have not succeeded in obtaining direct evidence of the formation of acetaldehyde or of formic acid, in the acetone fermentation, the proportions in which the end-products are formed accord well with the correctness of this explanation.

It may be mentioned in this connection that Neuberg and Ford have recently shewn that a certain butyric acid organism, when acting on glucose, does in fact give rise to the formation of acetaldehyde, and a good deal of evidence is accumulating to shew that this substance must be regarded as a very general intermediate product in the case of a great many fermentation processes in which yeasts and bacteria are the active agents.

With regard to the mechanism of acetone formation, the authors do not express any very decided opinion, but evidently incline to the view that the acetone is formed from the acetic acid. The process has been made the subject of study by several other investigators, and since the appearance of the paper by Reilly and his colleagues, a paper has been published by H. B. Speakman, who brings forward some evidence in support of the view that the acetone is produced from butyric acid with acetoacetic acid as an intermediate product. According to this explanation, the action would be represented by the following equations :—

$$2\ C_3H_7.COOH + O_2 = 2\ CH_3.CO.CH_2.COOH + 2\ H_2$$

n-butyric acid $\qquad$ Acetoacetic acid

$$CH_3.CO.CH_2\ COOH = CH_3.CO.CH_3 + CO_2$$

Acetoacetic acid. $\qquad$ acetone.

It is noteworthy that Reilly and his colleagues have also suggested that acetoacetic acid may be an intermediate product. In connection with this explanation it may not be without significance that hydroxybutyric acid, acetoacetic acid and acetone frequently occur in the urine in severe cases of diabetes and that it has been observed that the proportions of the two first named substances usually rise and fall together. It is evident that in the animal organism, therefore, there is a close genetic relationship between these three substances.

It is clear that the mechanism of the process is a very complex one, and further work on this subject will be looked forward to with considerable interest.

So far as the commercial possibilities of this process are concerned, it is tolerably clear that, if it is to compete successfully, in times of peace, with the ordinary process for the manufacture of acetone, several important conditions will have to be fulfilled.

In the first place, it will be obvious that the manufacture could only be carried out, with any chance of profit in those countries where the raw material (*e.g.*, maize, rice, *etc.*) is abundantly and cheaply grown, so that high freight charges on bulky material could be avoided.

In the next place, it will be necessary to find some profitable commercial outlet for the butyl alcohol, the quantity of which is twice as great as that of the acetone.

A process has been patented by Weizmann and Legg for the conversion of butyl alcohol into methyl-ethyl-ketone, and if this can be worked profitably, it may supply the solution of this particular part of the problem.

In addition to this, in order that the process might be an economically sound one, it would be necessary to find uses for the gases—or, at least, for the hydrogen—produced, and also for the constituents of the spent wash.

It is clear that much investigation is still needed before this process can be put on a satisfactory working basis, but it may be regarded as affording an excellent example of the need to which I have repeatedly called attention, for the extended study in this country of micro-biology in its relation to chemical industry.

Before leaving this subject, it may be of interest to note that Northrup, Ashe and Senior have recently described an organism which produces acetone and ethyl alcohol from starch or sugar. This organism, to which the name *Bacillus acetoethylicum* has been given, produces acetone, ethyl alcohol and formic acid, together with gaseous products. Its optimum temperature for the formation of acetone is 43° C., and it ferments pentoses as well as hexoses.

The point of chief interest in connection with this work is the fact that ethyl alcohol appears to take the place of the butyl alcohol formed in the process which I have just described.

I have now dealt with a number of industrial processes in which micro-organisms of one sort or another are the active agents. These I have used by way of illustration, my object being not so much to explain the technology of the processes in question as to indicate some of the general principles underlying them. Above all, I have been anxious to emphasise an important property of micro-organisms, which has not until within comparatively recent years, been made the subject of much study, at any rate, in relation to industrial processes. I refer to the way in which the nature of the chemical activities of these organisms may be made to vary according to the conditions under which they are compelled to function. To take an outstanding example: For a good many years the production of alcohol, carbon dioxide, glycerine and succinic acid in roughly definite proportions has been regarded as a fixed and characteristic property of yeast. This, of course, is due to the fact that yeast had always been studied under a certain set of conditions, *viz.*, those more or less favourable to what we know as alcoholic fermentation. As I have shown, however, in my first lecture, the proportions of the above mentioned products as determined by Pasteur, may be very greatly varied if the yeast is made to function under conditions differing widely from those associated with the ordinary fermentation of sugar. This is one of the lines along which research in the domain of industrial micro-biology is now advancing, and which may be expected to yield results of great technical importance. The number of industries in which micro-organisms play an important part is considerable, and in many of these the results cannot be obtained by any other means. To prepare a complete list would be difficult and would not serve any useful purpose. Leaving out of the question the wine industry and certain minor fermentation industries, such as the production of cider, I may refer briefly to the great importance of micro-organisms in agriculture, in bread-making, in the dairying industry, in tanning, in the treatment of sewage and finally in connection with the production of what may, perhaps, be termed synthetic food.

The very great importance of bacteria to the agriculturist is now well recognised, as the result of a very considerable amount of excellent work done during the past 30 years.

Of the various factors on which the fertility of the soil depends the bacterial flora is unquestionably one of the most important.

On the activity of the micro-organisms present depend the production of ammonia from nitrogenous organic matter, the oxidation of ammonia to nitrites and nitrates, the fixation of atmospheric nitrogen and other useful chemical changes.

It is not my intention—even if I felt myself qualified—to deal at any length with these various groups of bacteria or with the important part they play in agricultural practice.

The artificial supply of various cultures of the nitrogen-fixing bacteria which are symbiotically connected with the various species of leguminous plants, in their root nodules, has not perhaps been attended by the full measure of economic success which was at first anticipated, for the reason that in land that has been long under miscellaneous cropping, nature appears, as a rule, to have already established a sufficient supply of such organisms. But under some exceptional circumstances it has given hopeful results.

On the other hand, the study of the interaction of the protozoic *fauna* of the soil on the bacterial *flora* has led, in consequence of the work of Russell and his colleagues at Rothamsted, to results of great economical value in the intensive horticulture carried on under glass which is becoming an increasingly important industry. I allude to the productive effect of what is now well known as "soil sterilization" as a means of controlling the predatory action of mischievous protozoa on the "beneficent" bacteria which control the nitrogen economy of the soil, and so curing the "soil sickness" which was previously a bane in the highly manured soils of the green house.

And there are, doubtless, other directions in which we may look forward to a useful practical outcome of the increased attention which is being given to the micro-biology of the soil.

In no branch of industry is the influence of micro-organisms, for good or for evil, more potent and more obvious—even to the intelligent layman—than in the dairying industry.

Milk is pre-eminently a medium in which a very large number of organisms of various kinds are capable of developing freely, and, whilst some of these are useful for various purposes, others are exceedingly harmful.

Without attempting any comprehensive classification, it may be mentioned that there are usually present in milk, bacteria producing acids, gas-forming bacteria, bacteria causing slime or "ropiness," bacteria producing proteolytic enzymes, and many others, whose properties are not very clearly defined and which are possibly neither good nor bad in their effects. There may also be present bacteria capable of giving rise to disease in the human subject.

On what I may call the negative side, the need for a knowledge of micro-biology, as necessary to the production of clean and wholesome milk, is very great.

On the positive side, in which I am more interested this evening, reference may be made, in passing, to the use of "Starters" or acid-generators, that is to say, pure cultures of certain bacteria intended for the artificial souring of cream to be used for butter-making.

Since the year 1890, when this process was introduced by Weigmann, it has made very considerable headway in some countries and it has been stated on good authority that 98 per cent. of the factories in Denmark pasteurize their cream and use pure cultures of selected bacteria for the purpose of producing ripeness. To this practice, the uniform character and high quality of the Danish butter is said to be attributable.

Besides the artificially controlled souring of the cream, the addition of certain other bacteria for the development of flavour has been advocated and practised.

In the cheese industry, again, a knowledge of micro-biology is of the highest importance. As in the case of all ancient industries, recipes for making the various kinds of cheese have been handed down from father to son, and the procedure in the majority of factories is even now very largely conducted on rule of thumb principles.

The conversion of curd into cheese is a much more complex matter than might, at first sight, appear, and quite a number of bacterial and other enzymes are concerned in the transformation. During recent years, a considerable amount of scientific investigation into the biochemical changes connected with the manufacture of cheese has been undertaken, with which the names of Freudenreich, Mazé and Lezé are prominently associated.

The use of Penicillium mould in the production of Roquefort, and of selected bacteria in the manufacture of Brie, are

two examples of the application of scientific methods to this industry, and there can be little doubt that in the not very distant future, the manufacture of cheese will be put on a scientific basis comparable with that on which many other of the more highly developed fermentation industries rest.

Since there is very good ground for believing that the ripening of cheese and the peculiar flavours which are characteristic of the various kinds are due, largely, to bacterial activity, it has been often suggested that, by the employment of proper organisms under carefully controlled conditions, the flavour and other characteristics of any particular kind of cheese could be reproduced at will. A good many experiments have been made in this direction, both on the small and on a comparatively large scale, and have met with a certain measure of success.

It must not be forgotten, however, that the variations in the chemical functions of an organism, according to its environment, have their drawbacks, as well as their great advantages, from the point of view of the manufacturer. Since the normal activities of any particular organism are dependent on the conditions under which it is usually grown, it is obvious that any attempt to cultivate it under other conditions may give rise to quite different results.

In other words, even with the proper organisms, the cheese manufacturer in this country might still find that he had a long way to go before he could make a successful imitation of, say, a Roquefort or a Camembert cheese.

This difficulty is well-known to all fermentation technologists in connection with the attempts that have been made to reproduce, under artificial conditions, the characteristics of well-known wines. It is not, however, by any means insuperable, and with increased study, great progress will undoubtedly be made along these lines.

Another matter, to which I may just refer in passing, is the biological treatment of sewage and sewage sludge.

As is well-known, the disposal of the sludge is a matter of the greatest difficulty and importance. It is offensive in character and, owing to its colloidal nature, retains water with great persistence, a fact which militates against the attempt to concentrate it by pressing. The problem has, however, been solved by the biological method, and in Birmingham it has been stated, on the authority of Mr. O'Shaughnessy, that the process has dealt with the refuse of more than one million people over a period of eight years, and that the crude sludge treated amounts to 500,000 cubic yards per annum.

The bacterial, or so-called "Septic" process is carried out in special chambers, and when the digestion is complete, the sludge—now entirely devoid of colloidal character—is pumped on to shallow ash-beds, where the water separation takes place without any difficulty or offence.

The limited time at my disposal compels me to pass over several other industries in which micro-organisms play an important part, such as baking, wine and cider making and tanning. Among the less well-known applications of microbial activity, I may refer in passing to the employment of micro-organisms for the utilisation of the waste liquors from distilleries. This may be effected by employing certain species of bacteria and yeasts which produce amidases freely and by acclimatising them to work under the required conditions. In this process, as much as 85 per cent. of the total nitrogen can be obtained as ammonia, with some trimethylamine. These products are first separated from the fermented liquid after the addition of alkali. The liquid is then concentrated, acidified, and the volatile fatty acids are recovered by distillation. From the residue, certain acids such as malic and succinic may be obtained by crystallisation, the waste from the manufacture of one hectolitre of alcohol giving from 3 to 4 kilogrammes of crystallizable organic acids. According to Effront, who has worked out this process, a recovery plant in France which utilises the waste liquors from a single distillery, produces daily from 1,000 to 1,400 kilogrammes of nitrogen in the form of ammonia and trimethylamine, and from 10,000 to 12,000 kilogrammes of volatile acids. I refer to this merely to shew that biochemical methods for the disposal of waste material offer in some cases decided advantages over those in ordinary use, and there can, I think, be little doubt that such methods will in the future, find extended application in connection with other industrial processes.

I have now by way of illustration dealt with a number of industries in which micro-organisms play an important part, and have endeavoured to shew how greatly the chemical functions of an organism may be

varied, controlled and directed by appropriate modifications of its environment. A good deal has been written from time to time about the transmutation of bacteria, especially in connection with the causation of disease. In dealing with bacteria, it is very difficult to distinguish clearly between a *species* and a *variety*, the difference being one of degree rather than of kind. If, however, transmutation connotes the power of transmitting acquired properties indefinitely, then it may be said at once, that the great bulk of the evidence at our disposal tends to negative the idea. The more probable view is that the organisms in question merely adapt themselves to their new conditions of life, producing new enzymes to meet nutritional emergencies, and exhibit very little tendency to transmit newly acquired properties to succeeding generations, but rather to revert to the original type. What has been styled "impressed variations" may, of course, shew a considerable degree of permanence on the one hand, or a marked tendency to reversion on the other. It may be taken that the more readily a new character can be impressed on an organism, the longer it is retained, and conversely that the greater the difficulty in inducing an organism to acquire a new character, the more easily is that character lost. A good illustration of this is found in some experiments of Penfold, quoted by S. Gurney-Dixon in his recently published book on "The Transmutation of Bacteria." *B. typhosus* can be trained to ferment dulcitol in a few days and will then be found to retain the power for many weeks in the absence of that carbohydrate. It cannot, however, be trained to ferment lactose in less than two years, and then loses the power in a few days if that sugar is withdrawn.*

While on this point, I may perhaps refer to some recent experiments of Bonzomski on yeast. He found that when yeast was grown in a mineral solution, using asparagin or peptone as the source of nitrogen, and glycerol, mannitol, tartaric acid, malic acid or succinic acid as the source of carbon, the yeast produced no zymase, but apparently a larger amount of oxidising enzymes. In this medium and in the absence of sugar, the yeast became accustomed to the new conditions, and the velocity of reproduction which was small at first, rapidly increased. On transferring this zymase-free yeast to media containing sugar, it gradually recovered its power of fermentation, that is to say, its capacity for developing zymase.

I have so far confined my attention to certain useful chemical changes effected through the agency of micro-organisms, and I now propose to refer briefly to a somewhat different aspect of the importance of industrial micro-biology. I allude to the production of artificial nitrogenous foods. Yeast, like many other of the lower fungi, is characterised by an extraordinary power of reproduction, and by the ability to synthesize its protoplasmic cell contents with apparently great ease from a large variety of nutrient materials. It is somewhat difficult to estimate the amount of yeast produced in the breweries of the United Kingdom, but probably we shall not be far wrong in assuming it to be from 50,000 to 60,000 tons of pressed yeast per annum. Of this, a proportion is, of course, required by the brewer for starting his fermentations, but the great bulk is not so required, and is in the nature of a waste product. In Germany it has been stated on good authority, that the production of brewers' yeast in normal years amounts to about 70,000 tons per annum. At one time a great deal of brewery yeast was used in making bread, but this has now been almost entirely superseded by distillers' yeast, and many attempts have been made to find a profitable use for a waste product, which, as the following analysis shews, is possessed of considerable food value :—

AVERAGE COMPOSITION OF DRY YEAST.

Proteins and other nitrogenous substances	51.8
Yeast gum and other carbohydrate matter	28.5
Fat (Ether extract)	2.0

*C. Gorini (*Comptes rendus* 1921. 172. 1382) has made some interesting observations in connection with certain spontaneous and transmissible mutations in the case of Lactic Organisms. Whilst certain of these organisms normally coagulate milk and then bring about the solution of the curd, the same organisms may suddenly exhibit the property of peptonising the proteins of the milk in acid solution without, however, producing any curdling effect.

The organisms in which this change of properties has been observed and transmitted will often suddenly and without any apparent cause revert to their original characters. Gorini appears to refer the variations of properties observed in the case of lactic organisms to functional differences suddenly manifesting themselves in individual cells rather than to the existence of a considerable number of well defined species, races and varieties.

He concludes, with Charles Richet, that variations of this character in the case of one and the same species of organism are likely to assume a considerable and increasing importance in connection with physiological problems.

Mineral matter	11.0
Matters undetermined, including some cellulose	6.7
	100.0

The use of ordinary wet yeast for cattle feeding must of necessity be very limited, owing to its changeable character, and it has consequently to be dried in order to render it capable of being stored and conveniently transported to any required destination. Digestion experiments have shewn that from 90 to 95 per cent. of the total organic matter and about the same proportion of the nitrogenous constituents are available for animal nutrition. For a number of years this dried yeast has commanded a considerable sale in Germany, and owing to the high prices which the German farmers have been willing to pay for it, a good deal of the yeast dried in this country has hitherto found its way to the Continent. There is evidence, however, that farmers and stock breeders in this country are becoming alive to the value of this material as an economical and valuable adjunct to other feeding stuffs.

From the drying of yeast for cattle feeding purposes to the use of dried yeast for human food, was an obvious step. Here, however, the question of palatability assumed a higher degree of importance. Owing to the presence of hop resin and other impurities, the dried product was usually so bitter as to be virtually useless, but this difficulty was soon overcome, and both in this country and in Germany, dried yeast suitable for use as human food was prepared in somewhat considerable quantities. At the outbreak of war, the Germans were said to be producing in all about 20,000 tons of dried yeast per annum, of which a proportion was used for human food, as a constituent of a number of manufactured food stuffs. The use of yeast in this manner, is, of course, both obvious and crude, and for a long time attempts had been made to convert it into a more appetising and more attractive food product.

Following on the researches of Kossel and others, and on the recognition of the very great similarity existing between the products of hydrolysis of the protein and nuclear matters in the yeast cell, and those present in extracts prepared from meat, a good many patents for the manufacture from yeast of a food extract similar to extract of meat have been taken out in this and in other countries. The earliest patents date back to about 25 years ago and may be regarded as the commencement of the attempt to utilise yeast in this manner. About twenty years ago, the manufacture of such an extract was started in this country. The difficulties which were encountered at the commencement were gradually overcome as the result of scientific investigation, and at the present time, large quantities of a food extract, closely resembling meat extract in flavour and in general character, are being made and are being very widely used by all classes of the community. With the exception of the presence of creatin and creatinine in meat extracts and the absence of those bases in extract prepared from yeast, there is not, so far as is known, any material difference in the constituents of the two products. Recent physiological researches of the highest importance to the science of nutrition have shewn conclusively that the requirements of the human organism cannot be entirely met by an adequate supply of protein, fat, carbohydrates, inorganic salts and water, but that certain constituents which are variously designated vitamines or accessory growth substances are essential for normal growth and for the maintenance of health. These substances, which are present in minute quantities in various foodstuffs, have not, up to the present, been isolated and identified. It has, however, been shewn that there are at least two, the one known as the fat-soluble "A" accessory and the other as the water-soluble "B" accessory. Drummond and other investigators, working with the yeast extract "Marmite," have shewn that this is rich in the water-soluble accessory factor, which is not only necessary for the promotion of normal growth and nutrition, but also for the prevention of beri-beri and other nervous disorders and so-called deficiency diseases. In this respect yeast extract possesses a very great advantage over meat extract which, according to recent investigations, appears to be free from these important accessory growth-promoting substances.

Another very interesting example of the utilisation of the lower fungi for food purposes is furnished by the so-called "mineral" yeast which was manufactured in considerable quantities in Germany during the War and used for human food

purposes. From statements published during the War in the German technical press, it appears that one of the Professors of the Institut für Gärungsgewerbe in Berlin received in the early part of 1916 from a pupil of his on the Eastern Front a small specimen of a growth found on the stumps of certain trees in that district. After considerable investigation it was found that the growth contained an organism which exhibited some very interesting features. Thus, not only did it produce under certain conditions considerable proportions of fat, but it also had the property of building up protein from ammonium salts (without any form of organic nitrogen) in the presence of phosphoric acid and traces of compounds of potassium and magnesium. Inasmuch as ammonium salts could be obtained readily from the air, and since the carbohydrates resulting from the acid hydrolysis of wood could be used as a source of carbon, it was clear that this organism rendered it possible in the short space of 36 hours to build up fat and protein from such comparatively cheap raw materials as ammonium phosphate and the acid conversion products of sawdust. This organism is not a true yeast—that is to say, it does not belong to the genus *Saccharomyces* and it does not produce alcohol. As the result of the numerous statements appearing in the German technical press, Mr. Fred Wissler, Chairman of the Marmite Food Extract Co., Ltd., interested himself in this matter and a product was obtained from which, after some considerable difficulty, an organism was isolated, which if not identical with the German "mineral yeast," possessed very similar properties. The conditions essential for the growth of this yeast were minutely studied, and it was produced on a large experimental scale. By a special process, it was found possible to prepare from it a food extract closely resembling extract of meat in its chemical and physical properties, and so one had placed in one's hands the possibility of manufacturing through the agency of this microscopic organism, and in the course of a few days, a food extract closely resembling meat extract from such materials as glucose or converted sawdust, ammonium phosphate, and traces of certain other mineral salts.

It is well known that certain micro-organisms have the power of breaking down cellulose, and if one could succeed in finding a cheap and efficient biochemical process for the conversion of cellulose into sugar, the production of this synthetic food-material on a large scale would become practicable, even under peace conditions.

In a lecture delivered in Berlin in November, 1916, Hayduck — with true Teutonic enthusiasm—is reported to have said:

> "When we can convert our evening "papers into sugar so rapidly that we "are able, the following morning, to "eat for breakfast the albumen prepared "therefrom, then indeed shall we have "solved one of the greatest problems of "the century."

The problem which Hayduck had in mind, was not, however, the only important one which would be solved by the discovery of a cheap and efficient biochemical method for the conversion of cellulose into fermentable sugar. At the present time, and indeed at all times, the world's supply of starch is urgently needed for food purposes, and very little can readily be spared for the manufacture of industrial alcohol. The biological conversion of cellulose into sugar presents many difficulties, as I can testify from my own experience, but if, and when, such a process is discovered, the production of alcohol for power and general industrial purposes will be placed upon a very much more satisfactory footing.

In the course of these lectures, I have endeavoured to indicate the important part which micro-organisms play in a number of industrial processes, and the possibility of extending their sphere of usefulness, as the result of further research.

This leads me to the last point which I desire to put before you.

Anyone who makes an unbiassed survey of the work done in various countries in the domain of industrial micro-biology, cannot honestly feel satisfied with the contribution made by this country. Having regard to our position as an industrial nation and to the immensity of our Empire and, consequently, of our resources, we cannot regard with any complacency the fact that several nations are well ahead of us.

The statement that the wealth of a country depends upon its productiveness is one that is being made on all sides with almost wearying frequency, but, so far, there is very little evidence that it has had much effect. For far too many years, we have

been content to act as middlemen and agents, when we ought to have been manufacturers, and many of us hoped that the folly of such a course had been brought fully home to the nation as a result of the War. If we are not again to become dependent on other countries for our requirements, our manufacturers will have to adopt a very different attitude to scientific and industrial research from that which so many of them have shown in the past. This neglect has been especially great in the case of industrial micro-biology, regarded as a branch of chemical industry.

In these lectures, I think I have succeeded in shewing that, even in the case of long-established industries, empyricism is far too much in evidence. In a paper which I recently read before a meeting of the Society of Chemical Industry, I dealt at some length with this aspect of the matter and put forward a plea for a National Institute of Industrial Micro-biology.

There is not, in this country (nor, so far as I am aware, in the British Dominions), any institution devoted to a subject which covers such an immensely wide and varied ground and which is of such great national importance.

I am, of course, aware that a great deal of work in this direction is being done in existing institutions, but, as I pointed out in the paper to which I have referred, there is an entire want of co-ordination, accompanied by overlapping and waste of energy, and there is, above all, the important fact that the men engaged in teaching this subject (although possessing the highest academical qualifications) are frequently wanting in the necessary practical experience and knowledge.

It is true that some excellent work is being done in this country, but it is carried out in isolated institutions. Each of these deals with this immense subject in certain of its aspects only, and, as compared with a national institution such as I am advocating they suffer from the great disadvantage I have already mentioned, namely, that there is no co-ordination and that, consequently, combined attack on any of the big problems which are calling for solution is rendered very difficult, if not impossible.

The most important object of a National Institute would clearly be to provide for the systematic prosecution of original research in connection with all those industries in which micro-organisms, or enzymes, play an important part. There are, however, many other important functions which such an institution could exercise. Thus, it would serve as a centre for the specialised training of men intending to devote themselves to the teaching of micro-biology and biochemistry in our Universities and Technical Schools, as well as for the practical instruction of factory managers and other technical employees engaged in the various biological industries. It would, moreover, provide breweries, distilleries and other factories with any required organisms in pure culture and in sufficiently large quantities for industrial purposes. It would serve to house as complete a collection of industrial micro-organisms in pure culture as could be got together and, finally, it would serve as a central home for British micro-biological science.

Since my plea for the foundation of an Institute of Industrial Micro-biology was originally put forward, some progress has been made, and I am hopeful that such an institution may yet, before very long, come into existence.

I should like, in conclusion, to say what great pleasure the delivery of these lectures has given me, and to express the hope that they may serve in some small measure to direct attention to the claims of a branch of Applied Science which has not, hitherto, received in this country the degree of recognition to which its importance entitles it.

RAFFIA INDUSTRY OF MADAGASCAR.

Properly speaking, there is no organised raffia industry in Madagascar. Raffia, as commonly referred to, is not a grass, as is apparently often thought, but fibre taken from between upper and lower layers of the large pinnate leaf of the "raffia" palm, which is indigenous to Madagascar.

The raffia palm is not cultivated, but grows in a wild state, principally in the north and on the north-west and north-east coasts of Madagascar. The natives strip the fibre from the cut leaves. It is forbidden to cut or fell the tree itself, and only persons holding permits are supposed to gather this fibre. The permits are usually given without charge by the chief of the district and are valid for three months. The fibre, when stripped, averages about 1 inch in width, and from 3 to 5 feet in length, according to the width of the leaves from which it is taken. Often sections must be closed to the gathering of raffia because of too frequent cuttings of the leaves of the palm. The west-coast raffia is considered the better quality because of its

generally superior length and whiteness. The better colour of the west-coast raffia, particularly Majunga raffia, is perhaps due to its being subject to less rain, particularly after it has been stripped, than that which comes from the east coast.

The record year for raffia shipments was 1912, when 6,991,420 kilos (6,991 metric tons), was exported. In 1913 the quantity was 5,961,513 kilos. The exports since 1913 were as follows:—

	kilos.		kilos.
1914	4,024,044	1917	4,140,802
1915	4,712,794	1918	4,147,499
1916	4,728,724	1919	5,003,651

The amount during the first six months of 1920 was 5,373,622 kilos, or 369,971 kilos more than the total exports of this product in 1919. Previous to the War most of the raffia was shipped to France and Germany, where it was used in the vineyards for tying vines and for other horticultural purposes.

In addition to the exportation of raffia fibre, it appears from a report by the U.S. Consulate at Antananarivo that considerable business is done in rabannas (woven raffia sheets). These are made in the native villages. The ordinary plain rabannas are in sheets measuring about 9 feet in length and from 21 to 23 inches in width, while the coloured pieces are about 10 feet by 27 to 30 inches. There is also another rabanna, made of raffia and silk, averaging in length from about 10 to 15 feet, and 18 to 20 inches in width; but there has been no considerable export demand created for this class of goods. The ordinary plain and coloured rabannas have been used in Europe for upholstery, the material being strong and serviceable. Small handbags and other novelties are also made from this material. The quantity of these goods exported in 1913 amounted to 23,810 kilos or about 95,000 pieces. In 1919 the exports amounted to 27,988 kilos or about 112,000 pieces. During the first six months of 1920 these exports reached 63,950 kilos or 255,800 pieces.

THE CHINESE COTTON INDUSTRY.

It is expected that during the year 1921, China's cotton spindles will have increased to 2,225,000. The cotton spinning and weaving industry is for the most part centred about Shanghai, but it is also developing in a substantial way in Hankow and Tientsin. Mills last year earned dividends as high as 100 per cent. One of the prominent Chinese mills has averaged nearly 30 per cent. in dividends for the past 10 years, and one of the largest mills, British owned and operated, shows an average of 26.5 per cent. dividends over a period of 12 years.

As for cotton growing, it is estimated that the country now produces, under normal conditions, about 6,000,000 bales (of 500 pounds each) a year. The 1920 production was probably 50 per cent. normal. China is improving its cotton not only in quality, but also adding very materially to the quantity produced. Great interest is now being taken in the improvement of the native cotton which is so different from foreign cottons, that it will not hybridise, forming practically a distinct species. Thus, while there is considerable interest in the development of American cotton in China, there is a movement on foot to improve the native cottons by the method of selection. This latter idea was emphasised by an American cotton expert on his recent visit to China.

While Shanghai is at present the centre of the manufacturing industry in China and will probably maintain its lead in this direction, there is every reason to believe, writes the U.S. Commercial Attaché in China, that Tientsin and North China will develop very rapidly in cotton manufacture, owing to more favourable climatic conditions. Labour in the north can, on account of the favourable climatic conditions, work longer hours and with less fatigue than in the south. The labour element is one of the fundamental considerations in the cotton mill; hence it would be cheaper to manufacture cotton where labour conditions are more favourable than to try to confine its developments to sections in which cotton is principally grown, but which, on account of hotter climate, have less efficient labour. The future in the cotton-growing, spinning, and weaving industries in China, adds the Commercial Attaché, is bright and offers splendid opportunities for capital.

COIR INDUSTRY IN THE PHILIPPINES.

Practically no coir is exported from the Philippines and little progress has been made so far toward developing this industry. Over 800,000,000 coconuts are produced in the island annually; the cleaned fibre of each nut would yield about 0.22 pound of coir. Nearly 100,000 tons of unstripped coir fibre are annually burned, permitted to rot on the ground, or to float out to sea on the rivers that drain the various coconut-producing islands. At present, writes the U.S. Commercial Agent at Manila, the only coir mats made in the Philippines are the work of school children, who are taught to make the mats as a part of their industrial training. The methods used are necessarily simple. The coir is obtained from the fresh husk of the coconut by pounding it on a log or block with a wooden mallet. The husk is not retted, as it is found that good results can be obtained without this process, although a little more time is required. The extracted fibre is spun into coir rope by a simple apparatus made of a coal-oil box, a wooden roller, and a short piece of coir rope. Coir mats are then

made from the rope. All this work is done by children from 8 to 10 years of age.

The Philippine Board of Education alone is devoting attention to the production of coir, but its methods of manufacture are those described and the industry does not approach commercial dimensions. Anyone interested in obtaining a supply of coir might be able, adds the Commercial Agent, to arrange with the Bureau of Education through its sales department to undertake the production of a limited amount through the industrial schools in the coconut-producing Provinces.

BEET SUGAR INDUSTRY IN SHANTUNG.

The Pu Yih Industrial Co., organised by prominent Chinese capitalists at Peking, is establishing a beet-sugar factory at Wangtaichiao, near Tsinanfu. According to a report by the United States Consul at Tsinanfu, this represents the first effort in the direction of the establishment of a beet-sugar industry in Shantung following the success which, after a long term of years in carrying out experiments, has attended the industry in Manchuria.

Sugar-beet seed is being distributed in the districts around Tsinanfu, and the local magistrate has recently issued a proclamation urging the people to attempt a large-scale production of beets as a source of supply for the new industry.

A site, approximately 50 acres in extent, has been obtained at Wangtaichiao for the erection of the sugar factory, quarters for the workmen are said to have been already erected, and work on the factory itself was expected to be begun when the building season opened this year.

It is understood that the machinery to be installed is being ordered from the United States and Japan. A Japanese expert has been connected with the factory.

Whether the beet-sugar industry can be successfully established in Shantung still remains to be seen; although this attempt, if under efficient management, should represent a fair experiment. It has been found in Manchuria that the soil suited for the cultivation of the beet is fertile land, containing clay. But, generally speaking, on farm land where millet, beans, or wheat are raised successfully, the beet can be cultivated. Climatic conditions in Shantung appear to be favourable to the growing of the sugar beet, which has for years been a prominent truck-garden product in this district. It has been suggested that the Yellow River and the Grand Canal will furnish an unlimited supply of water for irrigation purposes in the Province; and as the best agricultural lands are the most densely populated districts, abundant supplies of labour are available.

Given proper conditions of soil and climate, which it would seem prevail in Shantung, and with abundant cheap labour, the principal elements for the successful establishment of a beet-sugar industry appear to be secured. Conditions of governmental encouragement or protection of the industry must be a matter for the future; and, if they are required, would be the subject of no easy adjustment. It is stated, however, that the Pu Yih company has been given a monopoly of the beet-sugar industry for 24 districts (out of a total of more than 100) in Shantung.

GRAPHITE IN MADAGASCAR.

According to a published statement of the Chief of Madagascar Service of Mines, quoted in the *Board of Trade Journal*, the quantity of graphite in stock in Madagascar on 1st April, 1920, amounted to 32,000 tons. The quantity exported during the period 1st April to 31st December, 1920, was 11,031 tons, leaving 20,369 tons, to which should be added the estimated production of 4,000 to 5,000 tons in 1920, giving an estimated stock of 24,000 to 25,000 tons at the end of 1920. No precise data are available as to the quantity of the different grades of graphite on hand, but approximately nine-tenths of the stock are flake graphite, the remaining being amorphous. Three-fourths of the flake graphite average 80 to 90 per cent. carbon, particularly of the old stock, the tendency now being to turn out an average quality of 90 per cent. and above because of the restricted demand for this article.

The record year for the production of graphite in Madagascar was 1917, when 35,000 metric tons were produced. The production in 1920 was between 4,000 to 5,000 tons, as compared with a similar quantity in 1919, and 16,000 tons in 1918.

Of the 14,919 tons of graphite exported from Madagascar in 1920, 3,288 tons were shipped in the first quarter, 3,070 tons in the second quarter, 5,307 tons in the third quarter, and 3,254 tons in the last quarter. Of the total shipments in 1920, 4,449 tons came to England, 2,127 tons went to the United States, and the remainder to France, with the exception of 51 tons shipped to Belgium. Shipments have again been reduced, and the only information to be had concerning the present demand is regarding a contract held by one of the large mining concerns for 2,000 tons to be delivered in the present year to France.

It is estimated that about 20 per cent. of the total production of Madagascar graphite is treated mechanically. There are perhaps not more than half a dozen plants equipped with machinery, which consists chiefly of drying, separating, and other devices, kept more or less secret.

CORRESPONDENCE.

ORTHOTYPE.

Miss Butcher seems determined to convict me of unfairness to Orthotype. My justification for the criticism to which she takes exception is the following paragraph from a note she sent me last year:—

> "INSTRUCTIONS TO THE FOREIGNER.
>
> The Reader should use a pointer and actually or in imagination *hide* the misleading vowel letters, a, e, i, o, u, y, ai, ea, etc., pronouncing only the 7 shorthand letters."

I quoted this before from memory, but is it worth while quibbling as to whether it is the "Teacher" or the "Reader," who has to hide the letters, and "read only the shorthand signs?"

A. E. HAYES.

[*This correspondence is now ended.*—ED.]

GENERAL NOTES.

AUSTRALIAN GEM TRADE WITH FRANCE.—Acting upon the advice of the French Mission which visited Australia in 1919, the New South Wales Government sent an expert to France to investigate the possibilities of trade in Australian precious stones. On his recent return to Sydney, states the *Industrial Australian and Mining Journal*, the expert expressed confidence that an important business between France and Australia will be done in the future. France, he asserted, is keen on securing the trade formerly held by Germany. Agents previously bought the precious stones on Australian diamond fields and shipped them to Germany, where they were cut and polished and distributed throughout the world. France is now in a position to take Germany's place, for she has made great strides in the gem-cutting industry, and the work being turned out is decidedly superior to that executed by German gem-cutters.

THE SIMPLON TUNNEL.—According to a Geneva journal, it appears that the second Simplon tunnel is now nearing completion. At the end of March, 10,369 metres on the southern side, and 9,076 metres on the northern side had been pierced. This is 98 per cent. of the total length of the tunnel. It is now ten years ago, in March, 1911, since it was decided to construct this second tunnel, and the work was undertaken by Switzerland in the following year. The first tunnel was begun in 1898, and opened for traffic in 1906. It appears that the new tunnel was actually pierced at the same time as the first one, in order to facilitate the aeration of the working. Its transformation from a mere gallery into a full-sized railway tunnel was started in 1921. Colossal difficulties were encountered during the construction of the first tunnel, as great hot springs had to be diverted and canalised. At a spot about 2½ miles from the entrance on the Italian side, the rock pressure was so great that 18 months were spent in piercing 50 yards only. The masonry at this spot is over two metres thick. Immense prudence and tenacity have been required for enlarging the first gallery at this danger spot.

PEPPERMINT INDUSTRY IN PIEDMONT.—A small but very profitable industry in Piedmont is the cultivation and distillation of peppermint. The communes which principally yield this crop are Vigone, Pancalieri, Villafranca Piemonte, Polonghera, Lombnasco, Casalgrasso, and Moretta. The crop for 1920 from this district was 100,000 quintals, or 22,000,000 pounds, obtained from 1,483 acres. The crop of 22,000,000 pounds after distillation produced 59,525 pounds of peppermint essence valued at 6,000,000 lire. According to a report by the U.S. Consul at Turin, the demand for Piedmont peppermint greatly exceeds the production, and the local distillers are endeavouring to increase the annual supply by promising higher prices to the cultivators. For the 1920 crop, the distillers paid 30 lire per quintal (220 pounds) for peppermint leaves. It is expected that the crop for 1921 will be approximately 20 per cent. larger than the 1920 crop, owing to the increased prices offered.

NEW SOURCE OF TANNIN IN FIJI ISLANDS.—It appears from a report by the U.S. Consul at Suva, Fiji, that a resident of Adelaide (Australia) has secured from the Government of the Fiji Islands the rights of all the Donga timber in that colony, and that a small company is being formed with a registered office at Suva. This is undoubtedly a most important development, as the Donga tree carries a thick bark which contains a very high percentage of tannin. The wood is also exceedingly hard and durable. The percentage of non-tannin in the liquid produced from the bark is so small that it easily outrivals the Australian and South African wattle bark, which hitherto has always held the leading position as a source of tannin extract. Considering what is now known of the cost of production, the price will be far below any tanning extract now in use.

SHIP BUILDING IN THE FAR EAST. — The launch of a large steamer at Saigon, the capital and principal harbour of French Cochin, has just been announced by the Parisian journals. This vessel, which bears the name of "Albert Sarrout," a former Governor of the Colony, is the first large cargo boat built in Indo-China. She has a length of 90 metres (295 feet), and 12 metres (39 feet 4 inches) in beam, and is of 5,000 tonnage.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

APPLICATIONS OF CATALYSIS TO INDUSTRIAL CHEMISTRY.

By Eric K. Rideal, M.B.E., M.A., D.Sc., Ph.D., F.I.C.

Lecture I.—*Delivered February 14th*, 1921.

Recent Developments in Catalytic Chemistry.

From time immemorial the alchemists had sought for the philosopher's stone, a mysterious substance which possessed the power of transmuting base metals into gold, the stone itself remaining unchanged. With the growth of chemistry as an exact science the philosopher's stone apparently underwent gradual deterioration; thus Raymund Lully found that the stone lost its efficacy after the transmutation of 10 billion times its weight of base metal into gold. Roger Bacon could only effect a one million transformation, whilst John Price, the last gold maker of the eighteenth century, only succeeded in transmuting thirty times the weight into the precious metal.

It was, however, Berzelius, in 1835, who first recognised catalytic action as a separate distinct phenomenon in chemical activity, and one which evidently required explanation. Berzelius drew attention to the curious fact that in a number of very diverse chemical reactions which had been investigated prior to that year, one of the constituents apparently remained unchanged. Thus in 1794, Mrs. Fulhame showed that small traces of water were necessary to promulgate the reduction of metallic oxides. Again, in 1812, Kirchof found that in the conversion of starch into sugar by means of dilute acids, the acid was unaffected.

Sir Humphry Davy in 1817 noted that platinum wires below a red heat promoted the combustion of many combustible gases with oxgyen, such as ether and coal gas.

These researches were rapidly followed by those of Thénard in 1818, on the decomposition of hydrogen peroxide in the presence of substances such as alkalis, finely divided metals and fibrin, of Edmund Davy, in 1820, on the oxidation of alcohol in the presence of finely divided platinum, of Döbereiner in 1822 and of Dulong and Thénard in 1823 on the action of platinum sponge in promoting oxidation of gases, a work which was continued in the next two years by Henry, who achieved some remarkable results. In 1831 we find Phillips, a British manufacturing chemist, taking out a patent for the use of platinum in bringing about the oxidation of sulphur dioxide by means of air—the forerunner of the modern-contact process, for the manufacture of sulphuric acid. In 1833 Payen and Persoz isolated the enzyme diastase from an extract of barley malt, and, finally, in 1834, Faraday commenced his epoch making work on "the power of metals and other solids to induce the combination of gaseous bodies," whilst in the same year, Mitscherlich showed that in the conversion of alcohol into ether, by means of sulphuric acid, this substance remained unchanged.

Thus, although we are indebted to Berzelius for the name catalysis, we find that Faraday, already a year before Berzelius, had realised the presence of a new factor in chemical activity, and had even advanced speculations as to its modus operandi.

From this time onward, the attention of investigators having been drawn to the occurrence of the strange phenomenon, the number of cases in which catalysis played

a part increased rapidly, and at the present time it would be a somewhat dangerous proceeding to cite any chemical reaction in which it was certain that catalytic action played no part. Accordingly the classification of catalytic actions has to be a perfectly general one, dependent not so much on the chemical nature but rather on the physical state of the system. Thus we can for convenience divide catalytic actions into:

(*i*) *Homogeneous reactions*, where the reacting system including the catalyst is in one phase, and as such we may cite the oxidation of sulphur dioxide to sulphuric anhydride utilising nitric oxide as a catalyst, or the conversion of starch into sugar, utilising sulphuric acid as a catalytic agent.

(*ii.*) *Heterogeneous reactions* or contact catalysis, where one of the reactants, products or catalysts is present, is another phase. The majority of industrial operations make use of catalytic reactions of this type, *e.g.*, the synthesis of ammonia from nitrogen and hydrogen with iron containing small quantities of alkali as a catalyst, the oxidation of sulphur dioxide and of ammonia in the presence of platinum, or the conversion of naphthalene into phthalic anhydride with the aid of vanadium pentoxide.

(*iii.*) Many processes of electrolytic oxidation and reduction include catalytic phenomena, either in the electrolyte or at the surface of the electrodes. Likewise must be included as a type of heterogeneous reaction, a great number of chemical actions taking place at surfaces, the so-called colloidal reactions. Colloidal metals such as nickel, platinum and palladium are utilised for hydrogenation of many diverse substances of which by far the most important industrial operation is the fat hardening industry. Apart from these inorganic colloidal catalysts the technical application of the organic colloidal catalysts, *i.e.*, the enzymes and the ferments, is of ever increasing importance. Enzyme chemistry having been the subject-matter of the last series of Cantor Lectures by Dr. Chapman, I will not attempt to review the recent progress in this wide field of catalytic activity.

(*iv.*) Finally, we must include a number of reactions in which radiation plays a part. The combination of hydrogen and chlorine is greatly accelerated by means of light. The reduction of silver halides to the metal by means of gelatine, and the interaction of chromates and gelatine in the presence of light, are the bases of the photographic processes in use to-day. The chlorination of hydrocarbons, the conversion of clays into more plastic substances under the influence of ultra violet light are all technical applications of the chemical effects of radiation.

Although of relatively slight industrial importance at the present time, the scientific interest in radiant catalysis can hardly be over estimated, since a study of interaction between radiation and matter offers investigators a new path of approach to that most interesting of all problems— the structure of matter.

Theories of Catalytic Action.

As we have already noted, catalysis enters into the most diverse types of physical and chemical change; accordingly, an explanation of the modus operandi of a catalyst postulates a knowledge of the mechanism of chemical action. The recent advances in the field of atomic structure, the dynamics of the atom and the nature of molecular orientation are gradually developing so as to give us a very faint picture of how this process may in reality be operative, but any theory of catalytic action must still be considered highly speculative. Berzelius himself believed in some occult force, the catalytic force, not entirely independent of the electro-chemical affinities of matter, but related to it in some inexplicable manner. Liebig took exception to Berzelius's postulate of a new force, but could not suggest any adequate substitute: he advanced the hypothesis that molecular vibrations were communicable by contact to another body, thus setting up in the atoms of the second system similar motions leading to reaction and decomposition. This view is one which cannot be submitted to a vigorous experimental test.

At the present time several diverse views are held as to the nature of catalytic action, which, although not entirely irreconcilable with one another, yet are sufficiently diverse in their fundamental postulates to demand continued investigation.

Although historically a theory of heterogeneous catalytic reactions, which still survives at the present day, was first advanced by Michael Faraday, yet it will be most convenient first to discuss homogeneous systems which superficially at least appear

to operate in a more simple manner than the former.

One of the earliest catalytic actions to be investigated was the inversion of sucrose into dextrose and levulose; similar examples of hydrolysis of esters, starches and cellulose are of great industrial importance. Wilhelmy noted that these reactions were accelerated by dilute acids, sulphuric acid, sulphurous acid and occasionally hydrochloric acid being then employed industrially. As a first approximation it was noted that the rate of hydrolysis was proportional to the concentration of the acid employed. Subsequent investigations notably by Ostwald and Arrhenius indicated that the various acids were not equal in catalytic activity, but that the so-called strong acids were more effective than weak acids. This naturally led to the view point that the catalytic activity of an acid was directly proportional, not to the acid concentration but to the hydrogen ion concentration. During the last decade, however, sufficient experimental data have been collected to show that this generalisation is by no means correct. It has been found for example that the addition of sodium chloride to an ester undergoing catalytic hydrolysis in the presence of hydrochloric acid has a very marked effect in increasing the rate of chemical action. On the addition of sodium acetate to an ester solution containing acetic acid, on the other hand, a slight diminution in the reaction velocity is observed. It appears very probable that this so-called neutral salt action may prove of great technical importance in the hydrolysis of substances like cellulose, which do not readily enter into reaction.

The early attempt to explain neutral salt action by postulation of an increased concentration due to removal of the water by hydration is no longer tenable, and at the present time two theories hold the field. The work of Dawson, Senter, Acree, Lapworth and others led them to the conclusion that not only was the hydrogen ion active as a catalytic agent, but that the undissociated acid molecule likewise possessed activity. Calculation indicated that, according to this theory, the catalytic activity of the undissociated molecule of a strong acid was nearly twice that of the hydrogen ion whilst the activity of the molecule of a weak acid was practically negligible, in consonance with the fact that the so-called neutral salt effect is practically non-existent in dilute acids such as acetic.

A series of the values of the catalytic activities of the undissociated molecules of various acids is given in the following tables:

Acid.	Catalytic Activity of $\dot{H}$	Catalytic Activity of Undissociated Molecule.
HCl	440	780
$H\,Br$	440	644
$C\,Cl_3\,COOH$	440	607
$C\,Cl_2\,H\,COOH$	440	220
$CH_2Cl\,COOH$	440	24.7
$CH_3\,COOH$	440	1.5

According to this view point, catalysis by means of hydrochloric acid on the hydrolysis of methyl acetate would proceed by means of two reactions.

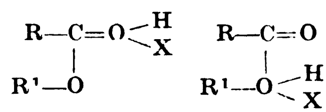
(*i.*) $CH_3\,COO\,CH_3 + \dot{H} = (CH_3\,COO\,CH_3\,\dot{H})$

$(\dot{H}.CH_3\,COO\,CH_3) + HOH = CH_3\,COOH + CH_3\,OH + \dot{H}$

(*ii.*) $CH_3\,COO\,CH_3 + HCl = CH_3\,COO\,CH_3\,HCl$

$CH_3\,COO\,CH_3\,HCl + H_2O = CH_3\,COO\,H + CH_3\,OH + HCl$

In support of this hypothesis the work of Kendall and of McIntosh may be advanced where a number of such ester acid addition compounds have been isolated. Kendall has furthermore indicated that strong acids form additive products more readily than weak acids, presumably of the oxonium types



The other theory of catalytic ester hydrolysis rejects the hypothesis of the catalytic activity of the undissociated molecule, it being argued that in the relative dilute solutions employed, and at the somewhat elevated temperature, the extent of additional compound formation between tho ester and the neutral undissociation molecule will, if it occurs at all, be so small as to be negligible. On the other hand, the hydrogen ion is regarded as the catalytic agent. That the catalytic activity is not proportional to the concentration of the hydrogen ions is attributed to the fact that as the concentration alters so do the physical and chemical properties of the medium. It is common knowledge that the properties of substances are governed by their environment, *e.g.*, the rate of diffusion, and it may reasonably be supposed that the catalytic activity of the hydrogen

ions varies with the nature of the medium in which they are dispersed; we are thus not so much concerned with the concentration of the catalyst but with the "activity" in its environment. Recently various methods for the determination of the "activity" of such catalytic agents have been indicated, and a very fair agreement between the activity and the catalytic effect has been observed, as is instanced in the following figures, obtained by Mc. C. Lewis in the hydrolysis of sucrose:

I. Velocity constants of hydrolysis divided by the water concentration 1 x 10^8	II. Activity of the Hydrogen in grm. mols. per litre	Ratio $\frac{I}{II} \times 10^6$
7.46	.060	1.24
8.53	.060	1.25
9.88	.078	1.27
11.58	.089	1.29
13.31	.105	1.32
15.61	.118	1.32
17.97	.139	1.29
20.33	.162	1.25

Another interesting fact to be noted in such chemical actions as we are discussing is that the rate of chemical action is far less than the number of collisions occurring per second between the reacting molecules. We are forced to the conclusion from this and other considerations that only a very small number of collisions are effective. It was at first supposed that the only successful collisions were those in which the molecules impinged on one another with a great velocity. This explanation has been found insufficient to explain the facts, and more recently it was supposed that successful collisions were those which took place between molecules which had absorbed radiation of a particular kind from its surroundings. The quantity of radiant energy taken up per grm. molecule or critical energy increment being given on the quantum theory by the relationship $E = Nh\ (\nu_1 - \nu_2)$. In other words, all chemical reactions were photo-chemical. This hypothesis has been extended very considerably by numerous investigators, notably by Trautz, Perrin, W. M. C. Lewis and Tolman. It has, however, been shown that there is not sufficient radiation energy of one particular wave length flowing into a reaction chamber in unit time to cause the number of successful collisions between the molecules actually observed, and certain experimenters, notably Langmuir, are inclined to reject the whole theory. It is, however, generally recognised that all substances, whether complex molecules or atoms, show under the influence of radiation, not a single line, but a spectrum of many lines. Analysis of these lines indicates that they are all related to one another in a single manner, and it is assumed that each line represents the occurrence of some specific action within the molecule, probably the movement of an electron from one stationary position to another, a process associated with the chemical phenomenon of activation.

Accordingly it may be supposed that molecules are activated to different degrees by resonance with or by absorption of radiation at frequencies corresponding to any one of these spectral lines, and that in a molecular assemblage, there exist molecules in all stages of activation. To bring a gm. mol. of these molecules to that stage of activation, where they will undergo a certain reaction, requires the addition of a certain amount of energy which naturally varies from molecule to molecule in amount dependent on their present energy content; the critical energy increment is, therefore, $E = Nh$ ($\bar{\nu}$ products $- \bar{\nu}$ reactants) where $h\bar{\nu}$ is the average energy to be supplied to each molecule. Since the radiation frequencies of the spectral lines are related to one another being frequently simple multiples of the fundamental infra red radiation frequency ν_0 we obtain

$$h\bar{\nu} = \frac{h\,\Sigma\nu_0}{n}$$

The function of a catalyst from this point of view is now evident. On a single radiation frequency hypothesis the only possible interpretation of catalytic acceleration was one of increase in radiation density, which in its quantitative aspects has been found to be deficient. On the spectrum hypothesis intermediate compounds are formed, permitting the activation to that degree necessary for chemical reaction with the catalyst by the absorption of smaller quanta: thus not only will there be more potentially reactive molecules present in the molecular assemblage but by the absorption of radiation which is more dense at that particular temperature, the reaction velocity will be greater than in the uncatalysed reaction where reliance had to be placed on the small number of very active molecules present and the slight density of the radiation necessary for

direct interaction of the molecules with the other constituents. The complex formed then reacts with the other constituents by the absorption of another small quantum. The sum total of the energy absorbed is, if the action is purely catalytic, again equal to the original amount of the uncatalysed reaction $= \dfrac{h\Sigma\,\nu_0}{n}$ but consists now of two or even many reactions, *e.g.*, the formation of the complex; and, secondly, its subsequent reaction and decomposition.

Applications of this hypothesis have been made to explain a number of reactions, such as the formation of ozone, the hydrolysis of methyl acetate as well as the various absorption spectra of organic substances.

The extension of the hypothesis to account for the effect of various solvents in shifting the position of equilibrium, has likewise been developed, but only as yet in a semi-quantitative manner, a matter which we need not go into here, since we are confining our attention to catalytic mechanism in which the catalyst is assumed to be present in quantities sufficiently small not to affect the position of equilibrium to any marked extent.

I have dealt at some length with the abstract development of this simple type of catalytic action, since the industrial applications which a better knowledge of intra-molecular reactions is bound to produce will be so vast and varied that it is likely materially to affect our mode of existence on this planet.

With heterogeneous catalytic actions we also note a tendency towards a more concrete visualisation of molecular kinetics, based upon a most varied, though each individually somewhat scanty, collection of data. Faraday, who was the first to propound a theory of heterogeneous catalytic action, suggested that the action of platinum in accelerating the combination of hydrogen and oxygen might be attributed to the absorption of these gases on the surface of the metal, and that the closer contact thereby occasioned stimulated reaction. An alternative hypothesis was advanced by Wöhler, who suggested that the platinum combined with the oxygen to form an oxide or even peroxide, and this then reacted with the hydrogen. Many catalytic reactions, however, would on this hypothesis postulate the existence of unknown chemical compounds with the consequence that the subsequent investigators have been more attracted towards the Faradayan hypothesis. During the present century numerous experimenters have investigated the reaction velocity of such reactions and have come to somewhat diverse conclusions. If it be imagined that the reactants hydrogen and oxygen are condensed upon the surface of the platinum somewhat like the atmosphere round the globe, then the rate of reaction occurring at the surface, if the surface reaction itself takes place rapidly, will be dependent on the rate at which the reactants diffuse through the absorbed atmosphere, and the products diffuse away. This diffusion theory has been ably supported by the work of Fink, Bodenstein and his co-workers. On the other hand, if the chemical reaction proceeding at the surface of the metal takes place very slowly, more slowly than the diffusion, the rate of reaction method will be a true measure of the catalytic rate. It seems certain that in many cases of heterogeneous reactions, *e.g.*, the hydrogenation of oils, with the aid of a nickel catalyst, the rate of diffusion is at least comparable to the rate of chemical action, and it is impossible to say how far the diffusion is an important factor in many other cases. Speculation from data on the velocity of such catalytic actions as to the mechanism of the reaction is consequently highly unjustifiable. In many reactions, however, especially gaseous reactions and those occurring at very low pressures, diffusion is not the important factor, and the velocity of the reaction does give some information as to the modus operandi.

It is fairly well established that the process of 'Sorption, as it is now generally termed, consists of three distinct reactions; firstly, the adsorption of a film over the whole of the surface of the catalytic material; secondly, absorption or the filling of the pores, cranies, capillaries of the catalytic material with the substance absorbed, the pressure inside the capillaries being very high. These can be calculated from a knowledge of the capillary diameters; and in all probability gases, even those not readily liquifiable, such as helium and hydrogen, exist therein in the liquid condition; and lastly, actual solution in the catalytic substances. In general, catalytic operations involve only the surface or adsorbed layer. But little is known as to its structure and

how it is formed, but in the phenomena of surface tension we find an almost exact parallel. The investigations of Hardy in this country and of Langmuir in the States had led to the important conclusion that the surface molecules are orientated. The significance of this fact can be most readily grasped from the following example. If a saturated fatty acid, *e.g.*, linoleic acid be dissolved in a little benzene, and the solution placed in a beaker containing water, the linoleic acid molecules will diffuse from the benzene to the water in which they are insoluble. At the interface between the benzene and water, there will be a number of linoleic acid molecules, which will all be arranged in an orientated position as in the diagram.

CH_3	CH_3	
CH_2	CH_2	Benzene
CH_2	CH_2	
——	——	
CH_2	CH_2	Water
COOH	COOH	

The carboxyl or acid (generally termed polar) group, will be pulled into the water whilst the aliphatic hydro-carbon chain (or non-polar group) will be pulled into the benzene. Similarly the non-polar groups in a molecule will stick out of the surface of a polar solvent such as water, to which it is attached by the polar groupings in the molecule. There appears to be little doubt that in heterogeneous catalysis the nature of the adsorbed film is similar to that obtaining at the surface of a liquid; the adsorbed film gives an adsorption compound which is quasi chemical in character as these are. We can, with these assumptions, advance a tentative explanation for the combination of two gases, *e.g.*, carbon monoxide and chlorine at the surface of the catalyst such as charcoal, the industrial process largely developed during the late war for the manufacture of the poison gas, phosgene.

The chlorine and the monoxide can be imagined to be adsorbed on the surface of the charcoal in orientated positions in juxtaposition to one another; combination ensues, and the products are desorbed or vapourise off the surface

Several interesting points are to be noted in this connection. Firstly, that every molecule striking the surface of the catalyst adheres for a longer or shorter interval before it either jumps off again or combines with its neighbour. Indeed, it appears likely

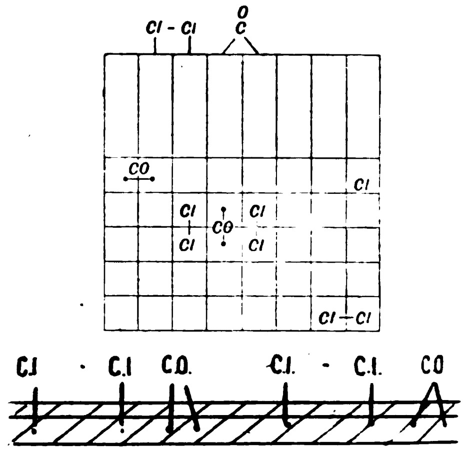


FIG. I.

that the quantum theory already referred to can be utilised in a similar manner to calculate the heat of adsorption and the number of crises occurring per second in the molecule. Again, it appears likely that reaction only takes place when a reacting molecule of each species is adsorbed in juxtaposition to the neighbouring atoms of the solid catalyst, although in certain cases, *e.g.*, the catalytic oxidation of carbon monoxide on a platinum surface, it is possible that only the carbon monoxide need be adsorbed. It must also be borne in mind that for any specific gas mixture and catalyst there is a certain temperature below which one gas is more strongly adsorbed than another, thus permitting the catalytic surface to be preferentially coated with one constituent.

The time of contact or the lengths of life of the molecules on the catalytic surface are also determining factors in the rate of chemical action. For effective catalysis the lives of the reactants should be equal (assuming a bimolecular reaction of the type $A+B \longrightarrow C$.), whilst that of the products should be very short. Unfortunately, in many cases, the product is more readily adsorbed than the reactants, and in consequence the area of catalytic active surface is reduced, giving rise to negative auto-catalysis. This hypothesis leads to the interesting conclusion in the case of two reactions proceeding simultaneously, that by the suitable choice of catalytic material, *e.g.*,

$$A+B \longrightarrow C$$
$$A+D \longrightarrow E$$

it should be possible to accelerate either one or the other reaction, the molecules of A

and B, in the former case having equally long lives on the surface, and of A and of D in the latter. Technical application of this principle is found in certain cases of selective combustion, which we shall have occasion to refer to.

It must, however, be emphasised, that adsorption of the reactants *per se* on the surface of a material will not necessarily increase the rate of reaction. Adsorption must occur in such a manner that the reactive groupings of each reactant are brought in contact with one another. As an example it may be mentioned that both methyl acetate and caustic soda are adsorbed from aqueous solution by charcoal, but the reaction velocity, instead of being increased on the addition of the charcoal, is actually very much decreased. On the other hand, charcoal accelerates the inter-action between α β dibrom propionic acid and potassium iodide. In the former case the reactive groups of the two reactants are orientated in opposite directions to one another, whilst in the latter they are brought into close contact on the charcoal surface, which thus functions as a catalytic agent.

Technical Difficulties.

From the industrial point of view one of the chief merits of catalytic reactions is the enormous reaction speed which may be obtained under suitable conditions with relatively small quantities of catalytic materials; thus five gms. of platinum will produce one ton of sulphuric acid per diem from sulphur dioxide, forty gms. of platinum gauze one ton of nitric acid from ammonia; 0.5 per cent. of acid only is required to effect the rapid hydrolysis of sugars, starches, and cellulose, whilst one part of palladium in 50,000 parts of castor oil is sufficient to effect complete hydrogenation in from 6 to 8 hours. Since it is evident that by a full utilisation of this phenomenon, the capital outlay and labour for manipulation in plants can be reduced in a most remarkable manner, the technical difficulties associated with all catalytic processes in general, and with those which have already attained industrial maturity in particular are worthy of the most serious attention.

The transference from the laboratory through the semi-industrial to the actual operating plant of homogeneous catalytic reactions, such as hydrolytic processes, usually presents but little difficulty; the catalyst is found to have a long life and the thermal changes associated with such processes are usually so small that no difficulty is experienced in maintaining the reactants at the optimum temperature. The recovery and utilisation of the products, however, often involves serious technical difficulties. Thus the recovery of alcohol and sugars from the hydrolysis of the pulp waste from paper mills, involves evaporation, and costs so much as to make the commercial exploitation of the process difficult except under favourable conditions. The recovery of alcohol in the process for the hydration of ethylene, produced in coke over gas in small quantities, involves a similar large evaporation cost. The full possibilities in the continuous catalytic production of ether from alcohol was only achieved after an elaborate investigation into the problem of the most suitable design for a rectification column from which ether, alcohol, and water could be simultaneously recovered had been solved. Up to the present time, no effort has been made to increase the activity of such homogeneous reactions, although as has already been pointed out, the phenomenon of neutral salt action indicates the theoretical possibilities of such an augmentation.

In the case of heterogeneous reactions, on the other hand, somewhat careful supervision is required and many interesting problems arise both in the design and operation of such plants. In some cases we have to deal with reactions which are markedly reversible in charcter, *e.g.*, the oxidation of sulphur dioxide or the formation of ammonia from its elements; both these reactions are strongly exothermic, the former evolving 21,700 calories per gm. molecule of SO_3 formed, and the latter 23,780 calories per 2 gm. molecules of ammonia. Even more energy is liberated in cases of selective combustion which we shall have occasion to discuss. Thus, in these cases temperature control is a very important factor, and the dissipation of the heat liberated during the reaction becomes a serious problem. Again, as we have noted that heterogeneous catalysis is primarily a surface phenomenon the most economical utilisation of the catalytic material is obtained with the maximum possible extension of surface, and much ingenuity has been exercised in the technical realisation of these important factors.

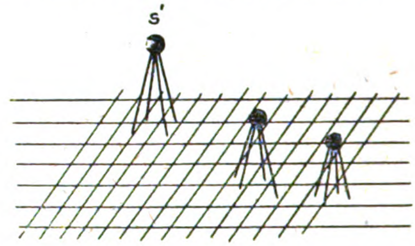
Heterogeneous reactions have developed industrially along two distinct lines, those in which the reactants are forced through or passed over a porous bed of the catalytic material, and those in which the catalyst is uniformly distributed in the reacting mass approximating to the conditions obtaining in homogeneous catalysis. It is evident that in both these cases the problems of temperature distribution and surface extension are widely different.

Apart from those physical factors involved, there are two chemical problems which always attend catalytic phenomena, termed catalytic poisoning and catalytic promotion.

Catalytic Poisons.

Although theoretically a catalyst should last indefinitely, yet actual experience has shown that from time to time the catalytic material has to be renewed, and it is thus customary to speak of the life of the catalyst. The catalyst may actually disappear by vaporisation, as is the case in the manufacture of sulphuric acid where 5 mgm. of platinum are vaporised away during the formation of one ton of oleum, or it may suffer chemical decomposition as in the manufacture of ether, where the sulphuric acid employed as catalyst undergoes gradual reduction to sulphur dioxide. In heterogeneous catalysis, however, it has been found that small traces of certain impurities retard or entirely prevent the action of the catalytic material. Thus it was not found possible to develop the contact process for the manufacture of sulphuric acid before a method was devised for the complete elimination of the arsenious oxide present in ordinary pyrites gases. The catalytic synthesis of ammonia involves special care in the removal of oxygen and sulphur containing gases, whilst the removal of sulphur and sulphur containing compounds must be accomplished before the selective combustion of carbon monoxide in hydrogen will proceed continuously. These impurities are retained by the catalyst and can be recovered from it. In general they are absorbed, although actual mechanical deposition, such as tar fog in certain gas works practice, or of oxide of iron and silica dust in the catalytic oxidation of ammonia, is occasionally met with.

Recent experimental work indicates that these absorption compounds are similar in character to those already discussed, but much more stable in character, there is reason for believing that the surface of a piece of palladium partially poisoned with sulphur would, to a microscopic observer, present somewhat the following appearance:—



One sulphur atom thus blocks up or poisons four active palladium atoms, and is very firmly attached. Hydrogen is very loosely attached, whilst the stability of the carbon monoxide absorption compound is intermediate between these two.

(J.C.S. 226, 119, 1921).

Some interesting experiments by Maxted, on the action of poisons in reducing the catalytic activity of platinum in the hydrogenation of oleic acid have confirmed the anticipated quantitative relationship between the decrease in catalytic activity and the amount of poison added to the catalyst.

The diminution in the catalytic activity of 0.005 gms. of platinum on the addition of small quantities of arsenic and mercury at 50° C. are shown in the following curves: (Fig. III).

Catalytic Promotion.

Although a tangible theory supported by a certain amount of experimental evidence has been advanced to explain the mechanism of catalytic poisoning, the phenomenon of catalytic promotion is much more mysterious and appears at present as a special compensation of Providence for the trials and troubles of industrial catalytic poisoning.

It has been found that the catalytic effect of a substance may be considerably enhanced by the admixture with the catalyst of small quantities of other substances. This in itself would not be so remarkable, if it were not for the fact that the promoted catalyst thus obtained is frequently much more active than either of the substances individually. Amongst the more important applications of promotion may be mentioned the use of mixed chromium and iron oxides in the water gas reaction, or reduced iron and traces of alkali in the synthesis of

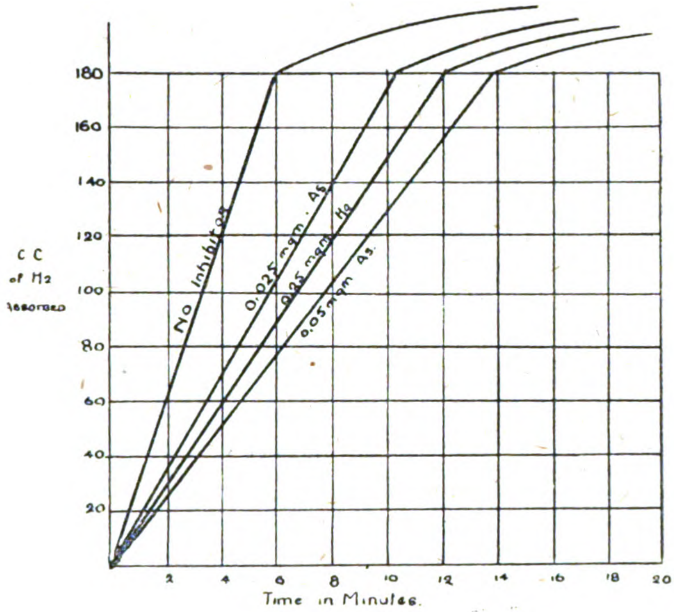
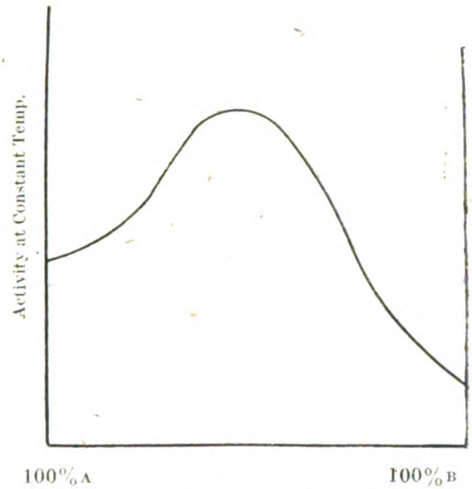


FIG. III.

ammonia, of mixed mercury and copper salts in the oxidation of naphthalene, of nickel and copper in the hydrogenation of oils and of small traces of ceria in the incandescent gas mantle. It has been suggested that the function of the promoter is chemical, *i.e.*, that the mixed catalyst is more active over a wider temperature range, since it provides a greater number of adsorption compounds than those catalysts which are not promoted, it being argued that the greater the number of adsorption compounds the greater the catalytic activity which is dependent on the formation of a labile complex of this type. This hypothesis has been extended to deal with the case of reactions of the type

$$A + B \longrightarrow C$$

Here we may imagine that the function of the promoter is so to adjust the composition of the adsorption film as to assist in the rapid sequence of the reactions (1) the adsorption of A and B in molecular ratios and (2) the desorption of C. Thus in the synthesis of ammonia, iron molydenum alkali catalyst is found to be extremely effective at 500° C. We may imagine that the iron preferentially adsorbs hydrogen and the molybdenum the nitrogen, although of course each metal adsorbs both gases with however a preponderance of one or the other, whilst the unction of the alkali is to desorb the mmonia as soon as it is formed. The typical curve for a catalyst promoted with only one substance would, from this point of view, be somewhat as follows:—



There is, however, another hypothesis which may be advanced to explain promoter action. We find on examination that the catalytic activity of even carefully prepared catalysts is very low: thus we can show by calculation that some 10 gms. of ethyl alcohol should undergo decomposition to aldehyde and hydrogen per sq. cm. of copper catalyst per second at 250° C., and at atmospheric pressure. Experimentally, several sq. metres of copper surface are required to produce the same yield. It is,

therefore, evident that but a small proportion of the metal surface is active, and it might be suggested that promoters increase the active surface. The most active catalysts are prepared by precipitation or decomposition under such conditions that the material passes through to the colloidal state; an increased activity of the surface may be accomplished by the addition of suitable peptising agents, and it appears probable that the maximum of surface thus produced is retained in the final catalyst. The microscopic examination, the sensitivity to temperature and the high chemical surface activity of these preparations all lend support to this view point. A typical curve for a promoted catalyst on this hypothesis would be somewhat as follows (Fig. IV): *a* represents the maximum peptisation of A with B as peptising agent, *b* that of B with A as peptising agent. An examination of the catalytic activity of palladium platinum gum arabic colloids as hydrogenating agents has indicated the likelihood of this hypothesis.

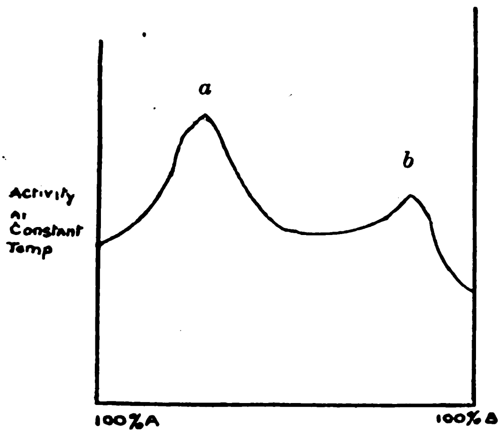
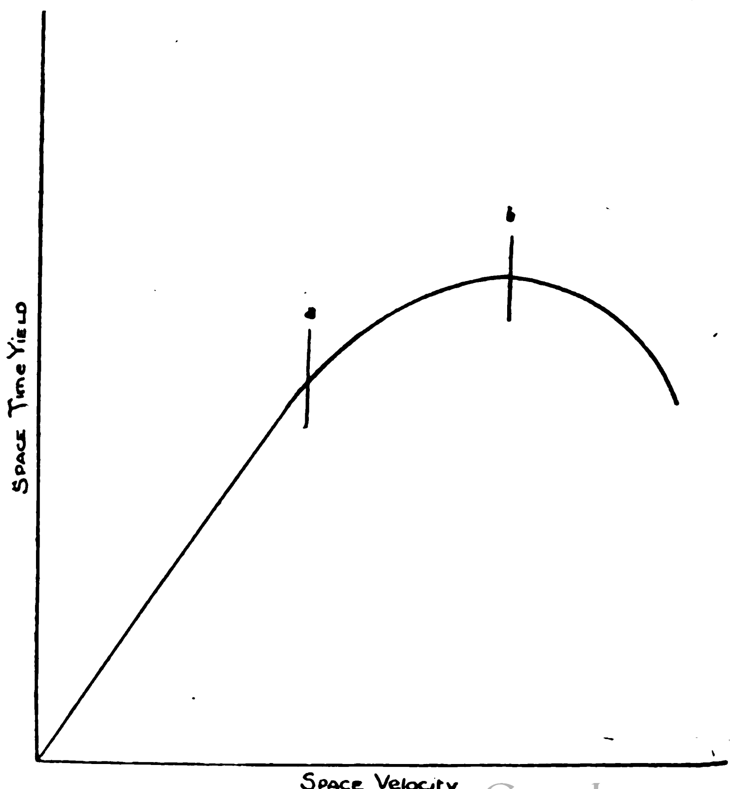
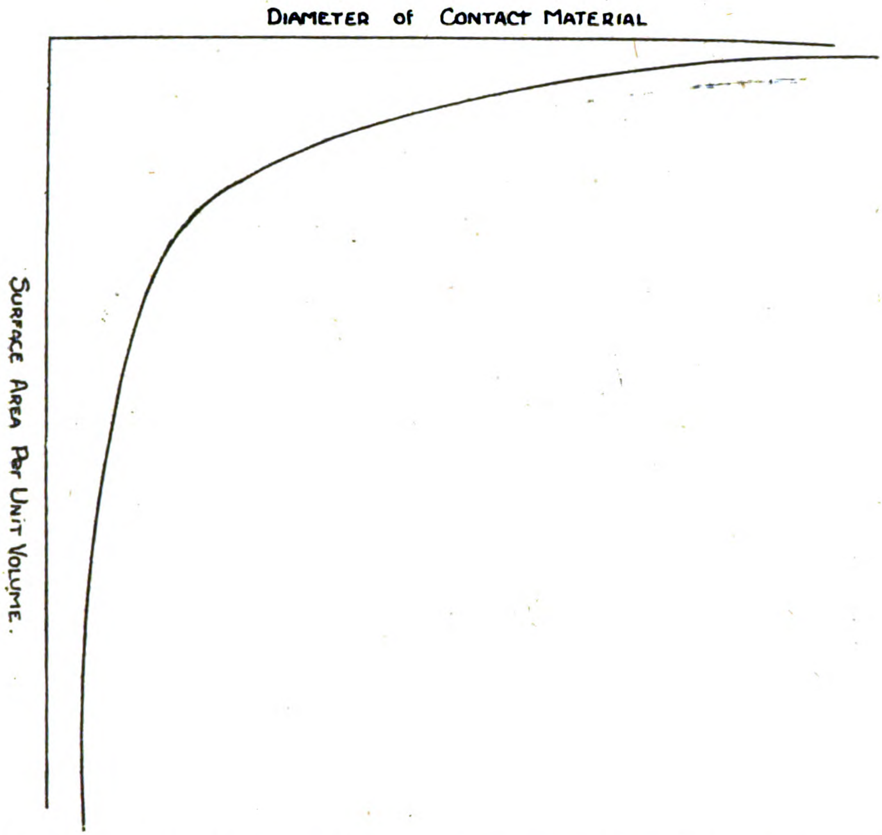


FIG. IV.

Heterogeneous catalytic plant design is a relatively complicated problem, since a number of factors have to be taken into consideration. At any given temperature a catalytic material will only operate at a fairly definite rate, if the reactants are blown through the catalyst at a known speed or space velocity V. A certain per cent. conversion will be effected, *e.g.*, X%. and the space velocity yield per hour or space time yield will be XV. For the product XV to be a maximum X is generally somewhat small and V very high. Under these conditions of course, the problem of





heat interchange of the removal of the products of the reaction and of circulating the gases round the system become extraordinarily difficult. For these reasons a relatively low space velocity is generally employed, allowing the reactants to attain almost complete equilibrium. The space time yield under these conditions is much below those attainable with the plant, but the cost of operation is also very much lower. With reactions which are strongly exothermic on the other hand, slow space velocities associated generally with a high percentage conversion give rise to great thermal changes in the reactants during their passage through the catalyst bed, a well defined temperature maximum being generally obtainable the zone shifting with changes in gas velocity. For this reason it is customary to grade the catalytic material and frequently to employ trays of the substance separated at some distance from one another with provision for abstracting heat by means of radiators at different parts of the catalyst chamber. In many cases dilution with inert gases such as nitrogen or steam is necessary. Calculations of the thermal data involved are necessary as a preliminary to the design of any catalytic plant. Thus, in three typical catalytic processes of oxidation, that of sulphur dioxide to sulphuric anhydride, ammonia to nitric oxide, and benzene to maleic acid. The type of plant employed is determined partly by the thermal changes occurring during the respective reactions. In the following table, the recently published data on this subject are summarised.

Reaction.	Optimum Temperature of Catalyst.	Reactant Oxygen ratio.	Heat developed in B.T.U. per lb.	Total Heat capacity of entering reactant-air mixture in B.T.U. per lb. (T25°—optimum).
SO_2—SO_3	400° C.	$2SO_2 : 3O_2$	635	661
NH_3—NO_2	750°	$NH_3 : 2O_2$	5660	6264
C_6H_6—Maleic acid	400°	$2C_6H_6 : 9O_2$	10561	1620

It will be noted that in the first case, if the catalytic material were active at 25° C., the effluent gas would attain the optimum temperature; since in general catalytic conversion will only proceed at a temperature of 375° C., it is evident that nearly 600 B.T.U.'s per lb. of SO_2 have to be eliminated during the reaction. In the case of the oxidation of ammonia catalytic conversion only commences at 500° C. Consequently pre-heating of the ammonia air mixture to this temperature is necessary before the gas mixture strikes the catalyst.

Nearly 4000 B.T.U.'s have to be removed by radiation for the optimum temperature not to be exceeded, whilst in the fractional oxidation of benzine, 10,000 B.T.U's per lb. of benzene have to be disposed of.

NOTES ON BOOKS.

ICONES OF THE PLANTS OF FORMOSA, AND MATERIALS FOR A FLORA OF THE ISLAND. Vol. X. By Bunzō Hayata, D.Sc. Published by the Bureau of Productive Industries, Government of Formosa, Taihoku.

The island of Formosa lies directly under the Tropic of Cancer, and it possesses many mountain ranges, the highest peak of which rises to a height of more than ten thousand feet above the level of the sea; it is easy to imagine therefore that its flora is enormously rich and varied, containing tropical, temperate and alpine groups. Indeed, so far as is at present known, there are 3,658 species and 79 varieties, belonging to 1,197 genera and 170 families.

Dr. Hayata set himself the task of describing and cataloguing this vast flora. He paid his first visit to the island in 1900. Although western botanists had previously studied the flora of Formosa, owing to the difficulties and dangers of travelling in the interior—including the presence of very active head-hunters—their explorations had been practically restricted to the coastal regions. A large portion of Dr. Hayata's work is, therefore, new to science.

The first volume was published in 1911, and this, the tenth volume, completes the survey. It contains studies on species and varieties, ranging from the Violaceæ to the Polypodiaceæ. The descriptions (which are written in Latin) are careful and elaborate, and the illustrations are good.

Dr. Hayata is to be congratulated on completing a task which must have involved an immense amount of labour, and we are glad to learn that in recognition of his work the Imperial Academy of Japan has awarded him the Prince Katsura Commemoration Prize.

TONCA BEAN TRADE OF TRINIDAD.

One of the most important articles of export from Trinidad, and one in which that island has a practical monopoly, is the tonca bean, the market for which is chiefly in the United States, where the beans are used extensively by various tobacco companies for perfuming smoking tobaccos. There is also a limited market for these beans in Europe, principally in France and Germany, where they are used in connection with the manufacture of various perfumes. The use of tonca beans by tobacco and perfume manufacturers, although apparently of considerable importance in many instances, nevertheless is, generally speaking, obscured in trade secrecy, and details as to its use are confined to manufacturers themselves.

According to a report by the U.S. Consul in Trinidad, tonca beans are not produced in that island, but in the forests of the Caura and Orinoco Rivers in Venezuela, where the trees grow wild in great numbers, with excellent quality of fruit, and large content of "cumarine," which is the active principle of the perfume, and gives the bean its commercial importance. Trinidad, however, has its part in the industry, being the place from which the beans are exported, by reason of the curing process being effected there. The beans are soaked in rum for a few days, after which they are spread out to dry for a short period. During the drying process innumerable small crystals appear upon the surface, giving the beans a frosted appearance, and emitting a strong and rather sickening odour. These crystals are the active principle of the perfume.

The export trade is controlled by one firm in Port of Spain, which manages the curing. This firm advances money to the collectors of the beans in Venezuela.

The exports of tonca beans to the United States show large variation from year to year and apparently depend a good deal on the prices, which fluctuate considerably. It is understood to be the policy of American manufacturers who make use of such beans to buy in great quantities and accumulate large stocks when prices are favourable and perhaps not buy at all when prices seem too high. In 1917 Trinidad exported to the United States 752,601 pounds of tonca beans, valued at \$472,055; in 1918 the shipments decreased to 19,213 pounds, valued at \$11,439, but increased in 1919 to 171,560 pounds, valued at \$167,221.

PRODUCTION OF SANTONIN IN RUSSIA.

According to data published by the Russian Division of the United States Bureau of Foreign and Domestic Commerce, santonin is a hard crystalline substance, the formula of which is $C_{15}H_{18}O_3$. It is extracted from the immature flower of the plant *Artemisia maritima* (*Artemisia cinea*), which is grown exclusively in the Kirghiz

Steppes of the north-western part of Turkestan —Syr Darya and Semiryetchensk Provinces— and in the Semipalatinsk Province of the steppe region of Siberia. The principal source of the crop of zedoary is generally considered to be between the cities of Tashkent and Semipalatinsk. Zedoary seeds, *Semen-contra*, can also be obtained from an African plant called *Flores cinea barbarici*, but this plant differs from the Turkestan species in that it contains a different chemical composition and cannot be used as a source of santonin. Thus, the only source of this product is the plant *Artemisia cinea* in Turkestan.

During the last few years the production of santonin was controlled by the Santonin Co. in Russia, which was in turn controlled by the heirs of I. I. Ivanov in Tashkent. Prior to the war the Santonin Co. sent its entire production to Germany to be refined, and received from that country about 15 poods (1 pood = 36.1128 pounds) of the refined product each year, which quantity was all that was needed for Russian consumption. Thus Russia had the monopoly of the production and Germany the distribution of that important medicine.

According to Russian official statistics, the amount of santonin exported from Russia to Germany and Great Britain during the years 1910-1916 was as follows (rouble at par of exchange = 2s. $1\frac{1}{3}$d.):—

Years.	To Germany.		To Great Britain	
	Poods.	*Roubles.*	*Poods.*	*Roubles.*
1910 ...	963	23,256	...	...
1911 ...	...	...	...	...
1912 ...	141	7,800	...	...
1913 ...	303	117,000	...	...
1914 ...	200	93,000	...	...
1915 ...	...	...	300	701,000
1916 ...	...	...	200	382,000

CINCHONA BARK AND QUININE PRODUCTION IN JAVA.

In the Netherlands East Indies the cultivation of the cinchona tree dates from about the middle of the nineteenth century. The home of the tree is in Peru and Bolivia, but it was found that the soil and climatic condition at altitudes from 5,000 to 6,000 feet in western Java were very favourable for its growth. The young trees are grown from seed and transferred from one bed to another until they reach the height of two to three feet, when they are finally planted in plots on the terraced sides of the mountains.

According to a report by the U.S. Trade Commissioner in Java, there are two methods of harvesting in use there at the present time. Either part of the plantation containing trees from three to four years old is cut down, or, on older plantations, a thinning out process is followed. The harvesting of the bark differs according to its being destined for pharmaceutical purposes or for the manufacture of quinine. In the first instance the bark is taken off in pieces of 10 to 40 inches in length and 10 inches wide, care being taken not to disturb the moss which grows on the bark, as this gives it a higher commercial value. When it is not necessary to preserve the moss, the bark is beaten with a mallet, and by this process is freed from the stem. The cylinders of bark are dried for a time on poles in a shady spot, after which they are put in the sun. They are finished in a drying room at a temperature of 100°C., care being taken to retain the silvery-white colour desired by the trade.

Until July, 1913, cinchona bark was sold by public auction in Amsterdam, but as the war disturbed the supply and demand and prices fell the producers held a conference with the buyers—about eight quinine factories—which resulted in a combination whereby the factories bound themselves to take up the Java production to a guaranteed quantity of bark containing 525 tons of quinine sulphate at a minimum price of 5 cents (1d. at normal exchange) per unit per cent. The manufacturers apply ten times a year for the quantity of bark each of them desires to receive. A control office controls the receipts, analyses, and deliveries of bark, fixing the quotations.

The Bandongsche Kinniefabriek at Bandoeng, Java, is the only manufacturer of quinine in the Netherlands Indies. The quantities of quinine sulphate exported from the colony all come from this factory. The following figures show the exports of quinine and cinchona bark for 1913 and 1916-19 :—

	Quinine. Metric tons.	Cinchona bark. Metric tons.
1913 ...	62	8,127
1916 ...	115	8,258
1917 ...	129	2,735
1918 ...	253	2,440
1919 ...	640	5,404

GENERAL NOTES

INSTITUTE OF METALS.—The autumn meeting of the Institute of Metals will be held in Birmingham on September 21st, 22nd and 23rd, when it is expected that the following papers will be submitted:—Professor A. A. Read, D.Met., and R. H. Greaves, M.Sc., "The Properties of Some Nickel-Aluminium-Copper Alloys"; R. T. Rolfe, F.I.C., "The Effect of Increasing Proportions of Lead upon the Properties of Admiralty Gun-metal"; R. Genders, M.B.E., B.Met., "The Casting of Brass Ingots"; T. G. Bamford, M.Sc., "The Density of the Zinc-Copper Alloys"; F. Johnson, D.Sc., "Experiments in the Working and Annealing

of Copper''; W. E. Alkins, M.Sc., and W. Cartwright, O.B.E., M.Sc., "The Effects of Progressive Cold Drawing upon Some of the Physical Properties of Low-Tin Bronze"; R. Genders, M.B.E., B.Met., "The Extrusion Defect"; F. S. Tritton, "The Use of the Scleroscope on Light Specimens of Metals"; D. H. Ingall, M.Sc., "The Annealing of Rolled Zinc"; D. Hanson, D.Sc., and Miss M. L. V. Gayler, M.Sc., "The Constitution and Age-Hardening of the Alloys of Aluminium with Magnesium and Silicon"; F. Adcock, M.B.E., B.Sc., "The Electrolytic Etching of Metals"; S. Beckinsale, B.Sc., "Electron" (the high magnesium alloy). The Lord Mayor (Alderman William A. Cadbury) will welcome the members to Birmingham, and give a civic reception in their honour at the City Art Gallery: The programme also includes a visit to the local University, and an address by its Principal (Mr. C. Grant Robertson, C.V.O., M.A.).

Calcium Malate from Waste Apples.—Some time ago, writes the United States Consul at Yarmouth (Nova Scotia), there appeared in the columns of a local newspaper an article on the discovery at Annapolis of a method of extracting by-products from waste and otherwise useless apples. A further press report has now appeared, which states that it has been found that even the most intensely acid and usually worthless apple may be so treated by a simple process as to yield syrup which has been pronounced eminently desirable as a basis for other concoctions not hitherto so well supplied. And not only is this syrup valuable, but another by-product has become evident in deposits of calcium malate, the same article as is derived from maple syrup and known as sugar sand. Before the war, the Germans bought this up extensively in Quebec at $1.50 or more per pound as a source of malic acid. The process is being carried on in two evaporators and may lead to the development of an entirely new industry in Nova Scotia. The Consul adds that experiments are still going on, but that at present no further details will be made public.

Mongoose Skins in Trinidad.—The mongoose was originally introduced into Trinidad from St. Lucia for the purpose of ridding the island of both rats and snakes, but at the present time it is itself considered a very serious pest. Moreover, the sugar production of Trinidad has diminished somewhat during the last few years, chiefly because of the ravages of frog-hoppers, since the lizards which formerly kept them in check are being exterminated by the mongoose. In fact, many estate owners in Trinidad pay a shilling a head for every mongoose destroyed on their estates, and many thousands are destroyed every year without any attempt being made to save the skins. The United States Consul in Trinidad calls attention to this matter and suggests that possibly these mongoose skins might have considerable economic utility.

Agriculture in China.—China, with its enormous population of 400,000,000, is, excepting, perhaps, the United States, the greatest agricultural nation of the world. In 1919, more than 80 per cent. of China's foreign trade consisted of products closely allied with agriculture. The Chinese farmer is generally the proprietor of his own land. Farming is on a gardening basis, and the individual holdings are comparatively small. In the coastal plain and Yangtse Valley, which is very thickly populated, the average farm is about an acre in extent. Cultivation is intensive and often three or four crops, such as cotton, beans, cabbage and corn, may be seen growing on the same patch of ground, not separate plots, but "between the rows." Methods worked out by the Chinese farmers have maintained the fertility of the soil for 1,000 years; but they have not developed their farming implements. Chinese ploughs, hoes, rakes and harvesting implements are of a type as old as the pyramids of Egypt. The beast of burden in south and central China is the water buffalo; whilst in North China, Manchuria and Mongolia it is the mule, pony, and sometimes the ox and camel.

Reconstruction in the Devastated Regions of France.—It was stated lately in the French Senate, that 90 per cent. of the area of the devastated regions in France had already been prepared for cultivation. Of this, about 80 per cent. is now under cultivation. About half of the manufactories and works that had been destroyed during the war have been re-opened. Ninety-nine per cent. of the railway lines, which had been more or less destroyed, had been reopened, and about half the number of bridges and other works rebuilt.

Swedish Water-Power Stations.—At the close of 1920, according to *Swedish Export*, the aggregate power used in Swedish hydro-electric stations amounted to about 1,200,000 h.p., to which must be added about 260,000 h.p. (135,000 h.p. for the State and 125,000 h.p. for private concerns) which were in course of equipment. The Government power station at Motala and the extension of the Porjus station, and also the Bergslag station at Forshuvudfors, are also approaching completion.

Lahore Water Supply.—A new scheme for the water supply of Lahore, India, has been prepared by the municipal engineer. He proposes to take the water from the river Ravi, instead of from wells as at present, by mear ˆ pumps, and to deliver it to six settling tanks at Bodaminh. The city reservoir, says *The Engineer*, would be increased in capacity and a new one built. It is estimated that the scheme will cost 24 lakhs of rupees.

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FRIDAY, AUGUST 19, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

APPLICATIONS OF CATALYSIS TO INDUSTRIAL CHEMISTRY.

By Eric K. Rideal, M.B.E., M.A., D.Sc., Ph.D., F.I.C.

Lecture II.—*Delivered February 21st*, 1921.

Processes of Catalytic Oxidation.

Three different types of catalytic oxidation processes may be considered; those in which the operation of oxidation is complete, those in which fractional oxidation occurs, and finally, processes of selective oxidation, which latter include some of the most interesting of catalytic phenomena.

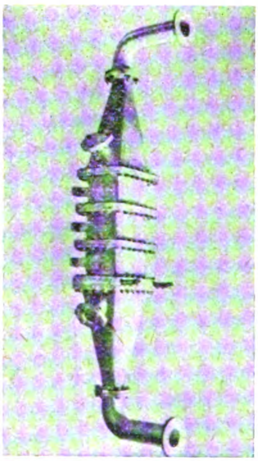
Cases of complete oxidation are well exemplified in the heavy chemical industry, including the two processes for the manufacture of sulphuric acid, the oxidation of ammonia, and the oxidation of hydrochloric acid to chlorine by the Deacon process; this latter owing to the development of the electrolytic alkali industry is now in its decadence. In the lead chamber process still most economical for dilute acid, no change in the catalyst-oxides of nitrogen has been proposed, but great changes in plant design have taken place in which we are not at the moment concerned. In the well-known contact process, owing to the shortage of platinum, very many ingenious attempts have been made to obtain a highly extended surface, of which, perhaps, the now well-known magnesium sulphate method is most effective. Microscopic examination of the Schröder Grillo catalyst reveals the fact that small craters are formed in the magnesium sulphate hydrate during ignition in sulphur dioxide, and the reduced platinum salt collects together in the form of gray platinum round the fringes of the craters; the dispersion is, consequently, very high. Attempts to substitute non-platinum catalyst operative below 400°C. have proved successful according to the patent literature, but have not yet attained industrial importance. It would appear that vanadium pentoxide deposited on silica may be prepared in a form the activity of which is no less than that of platinum itself.

The effect of the War on the heavy chemical industry was to stimulate the development of the process for the oxidation of ammonia to nitric acid, a process which in Germany attained enormous dimensions. How far this process will remain as a permanent feature on the industrial landscape is somewhat doubtful, since the differential market value of nitrogen in the two forms ex Haber or gas works ammonia and Chile nitre is not sufficient for economic operations. As a war measure, of course, the process is necessary and small applications are to be found even in peace time, such as in connection with the lead chamber plants for sulphuric acid manufacture, and the production of liquid NO_2.

The primary reaction may be represented by the following equations: $4\ NH_3 + 5O_2 = 4\ NO + 6\ H_2O + 215{,}600$ cal.; the nitric oxide being subsequently converted into nitrogen peroxide on cooling followed by absorption in nitric acid towers, with the production of somewhat dilute acid.

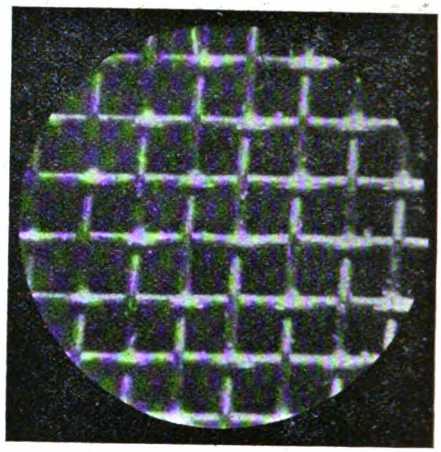
In principle, the operation of the plant presents no difficulties; filtered air is passed through a contact tower containing ammonia liquor, the compartments of the tower being maintained at suitable temperatures to give an almost ammonia free effluent liquid, and an air ammonia ratio of from 5-11 per cent., the exact ratio depending on the nature and efficiency of the catalytic agent through which the gas is next forced. Cooling of the gas

mixture in air and water cooled condensers, followed by water absorption, completes the process. As has, however, already been indicated, the margin permitted for operating costs is very small; a high efficiency and low capital and operating costs are fundamental to the actual economic existence of the process. The factors governing these desiderata fall under two heads, the catalyst chamber and the absorption system. The earlier plants of Ostwald used a system of nickel tube heat interchangers and a corrugated platinum foil roll weighing some 50 gms. The output for each converter was only 30 tons per annum. These comparatively expensive plants have now given place to the gauze type, which are practically standard when platinum is utilised as catalytic agent.



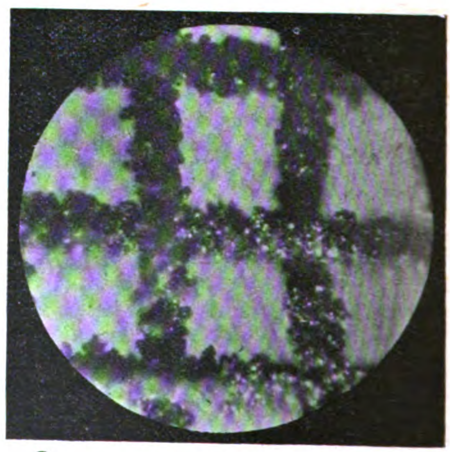
Ammonia Oxidiser.

It was soon found, on closer investigations, that if the catalyst itself were maintained at a bright red heat, no heat interchanger was necessary, the radiation from the red hot surface being quite sufficient to preheat the entering gases. Pure platinum gauze is generally employed 80 meshes to the inch and .0025 diameter wire, either one, or preferably two or more, mounted in an aluminium frame from the catalytic unit which can be readily removed from the converter in case of necessity. An air ammonia mixture containing 10 per cent. by volume of the latter is generally employed. The oxidation is started by means of oxygen hydrogen flame. The changes taking place in the appearance of the catalyst with continued use are somewhat interesting. A new platinum gauze which, even with a 75 magnification appears tolerably smooth



Fresh Platinum Gauze.

and bright, is practically inert as a catalyst, hardly any conversion being effected. If pure ammonia be employed the catalytic activity gradually increases, the maximum being attained only after several days of unknown operation. During this period the appearance of the gauze gradually changes, minute craters appear, and on careful examination it is observed that the lip of each crater is lipped with grey platinum, the gauze losing its smooth metallic appearance; the time of contact necessary for catalysis being simultaneously reduced from



The same after six weeks.

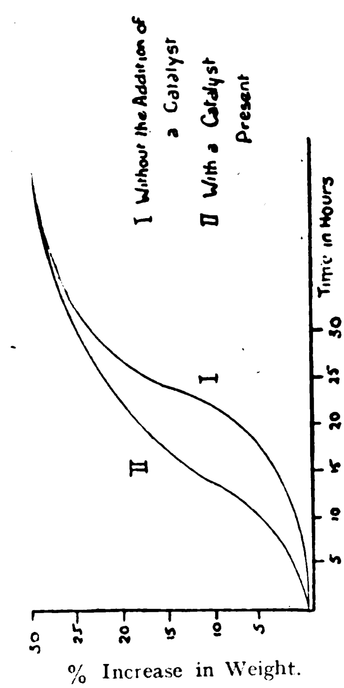
0.1 sec. to as little as 0.0006 secs. Black platinum, on the other hand, is too active; a low yield of nitric oxide is obtained due to secondary catalytic decomposition.

$$2\ NO = N_2 + O_2$$

The average yield per square foot of converter area with 2 gauzes weighing some 80 gms. is nearly two tons per day. The overall efficiency of such a plant is 92 %, and of the converter itself frequently as high as 95 %. Owing to the cost of platinum, numerous attempts have been made to utilise non-platinum catalysts. These were in operation in Germany during the war, but are now discontinued owing to the fact that they are much less efficient. the overall efficiency being only some 80 %. As catalysts small briquettes of oxide or iron containing suitable promoters, such as bismuth oxide, cerium oxide, manganese oxide and other similar polyvalent oxides were employed. The time of contact necessary at 800°C. is necessarily much longer than with platinum, being 0,1 to 0,2 seconds. In consequence, secondary decomposition is much more marked, accounting for the lower yield. With cyanamide ammonia, on the other hand, the appearance of the platinum is very different to that when pure ammonia is employed. Instead of crater formation the metal becomes crystallised in appearance, and a big loss of the metal is frequently occasioned by small crystals being blown from off the surface. No explanation of this curious phenomenon is as yet forthcoming, but it may in part be due to the fact that cyanamide ammonia contains small cases of phosphine, which reacts with the platinum to form a phosphide. At high temperatures, the phosphide undergoes oxidation to the original metal, and phosphoric anhydride. It would appear that this re-action is not a purely surface action, as is the case with ammonia, but that the platinum phosphide diffuses into the metal.

The chief drawback to the process is the large absorption system required to recover the somewhat dilute oxides of nitrogen. If oxygen be employed instead of air, apart from the extra expense incurred, the mixture of ammonia and oxygen is extremely explosive. It will be noted, however, that the primary product of combustion is nitric oxide and not nitrogen peroxide, owing to the high temperature at which the reaction proceeds. Nitric oxide oxidises but slowly into nitrogen peroxide at ordinary temperatures, and is but slightly soluble in water. It is thus found possible to dilute an ammonia oxygen mixture with steam, and after conversion, rapidly to cool out the excess of water and recover either liquid nitrogen peroxide or concentrated nitric acid. In the process for the synthetic production of ammonia liquid air is generally employed as a source of nitrogen; it is thus evident that the oxygen fraction of the liquid air plant would be available for the conversion of part of the ammonia produced into nitrogen peroxide and concentrated acid. It would thus appear that a small ammonia oxidation plant could be operated economically, in conjunction with a relatively large synthetic ammonia installation, but scarcely under other and less favourable conditions.

One of the oldest processes of fractional oxidation involving a catalytic reaction which of later years has attracted the attention of many investigators is the process of oxidation of the unsaturated fatty acids and their esters, the basis of the drying oil and linoleum industry. It has long been known that the conversion of linseed oil into linoxyn was a process of oxidation. Genthe, however, found that this oxidation was an auto catalytic reaction; in other words, during the oxidation itself a catalyst was formed which accelerated the reaction. If the increasing weight of a linseed oil film exposed to the air be plotted against the time the peculiar S curve is obtained.



The addition of catalysts to the oil very considerably accelerates the velocity of oxidation; most effective as catalytic agents are the oil soluble salts of certain metals technically known as siccatives or driers, linolates and resinates of polyvalent elements, such as cobalt and manganese are frequently employed. (A very complete experimental survey of the action of siccatives has been made by Ingle and his co-workers J. Soc. Chem. Ind. 35. 454 1916, 36 317 1907.) Of equal interest is the fact that the reaction is likewise catalytically accelerated by light, especially ultra violet light, such as is derived from a quartz mercury vapour lamp, a process occasionally employed for the production of linoleum. Thin films of linseed oil maintained in an air current at suitable temperatures are slowly passed over rollers exposed to the radiation, oxidation ensues and when the film becomes sufficiently tacky, the suitable design and colours are forced into the film by stamps and the roll is then completely hardened by continued oxidation.

The chemical reactions ensuing during the reaction are extremely complicated, primarily saturation of the double bond in the unsaturated fatty acid occurs with the formation of a peroxide, which on the elimination of water is converted into linoxyn.

On continued exposure to the atmosphere, however, a disintegration of the linoxyn with the production of traces of aldehydes and the oxides of carbon takes place. This secondary decomposition is of extreme importance in the preservation of oil paintings; it will be noted that in very old paintings, the varnish film cracks and eventually completely disintegrates, mainly a photo chemical catalytically accelerated reaction. Certain colouring matters incorporated in the oils as well as many water colours are extremely light-fugitive, the decomposition occurring under the influence of illumination being frequently a process of oxidation similar to that obtaining in the case of linseed oil, the phenomenon of catalysis playing an important part in the gradual disappearance from the world of masterpieces of art, of which some of Turner's and Tintoretto's paintings are good examples.

In entirely another field of organic chemistry processes of catalytic fractional oxidation are important, namely, the preparation of acids by the oxidation of the hydrocarbons. In 1906 Sabatier and Maihle showed that small quantities of aldehydes and alcohols would be produced by the catalytic oxidation of some paraffin hydrocarbons at 200°C. in the presence of copper, nickel and cobalt oxides. A year later Woog claimed to have obtained a 20% yield of benzaldehyde utilising ferric oxide as a catalyst. Neither of the investigations, however, indicated the possibility of a commercial development of the method, and gave no insight into the conditions necessary to obtain good yields. During the last two years, however, the matter has been re-investigated, with the result that one important technical operation is performed by direct catalytic oxidation.

In the synthesis of indigo, and for the production of many less important organic chemicals, phthalic anhydride is utilised in large quantities. Until quite recently, fuming sulphuric acid was employed as oxidising agent for the oxidation of naphthalin to this body, the reaction velocity being accelerated by mercury salts or by mercury and copper salt mixtures, an interesting and typical case of promoter action. It has, however, been found that if naphthalin be vaporised in an air current and passed over specially prepared vanadium pentoxide at 350°C. an almost quantitative yield of phthalic anhydride is obtained.

Benzene can likewise be converted into the dibasic fatty acids. Both these reactions are strongly exothermic, and a suitable design for the catalytic chamber was the chief difficulty associated with the industrial development of the process. It is evident that once the plant is in operation, crude naphthalene and air are the only raw materials required, and pure phthalic anhydride is produced; the cost of operation being negligible.

Much more difficult but of great industrial importance is the possibility of the direct oxidation of the higher paraffins, *e.g.*, paraffin wax to the corresponding fatty acids, according to the reactions

$$CH_3\,(CH_2)_{15}\,CH_3 \rightarrow CH_3\,(CH_2)_{15}\,COOH$$

or to the aldehydes or alcohols

$$CH_3\,(CH_2)_{15}\,CHO.$$
$$CH_3\,(CH_2)_{15}\,CH_2\,OH$$

The products obtainable from such a process of fractional oxidation of such a cheap raw material as the paraffins are very varied in character. Most important are probably

the fatty acids which can be directly employed in soap and candle industries; opinion as to the nutritive value of the fatty acids is still not unanimous, but it would appear that the organism can assimilate this material, although not so readily as the glycerides of the acids ; if more extensive nutrition experiments condemn free fatty acids as a food stuff catalytic esterification with glycerol or more probably with a cheaper alcohol, such as sugar, might prove of considerable value as an augmentation of the food supply in times of stress.

The production of waxes such as (Myricyl Palmitate) beeswax largely employed for the production of honeycomb, for floor and boot polishes, in the paint, varnish and many allied industries, would alone render the solution of the problem one of no mean industrial importance.

During the last two years this problem has attracted great attention on the Continent, where several preliminary papers on the subject have already been published. A comparative summary of these indicates either that great attention has not been paid to a matter of accuracy of statement, or that, for economic reasons, they are wilfully misleading. There appears, however, to be little doubt that it is possible to effect the fractional oxidation of a crude paraffin wax with a 90% yield of the higher fatty acid and waxes, under suitable conditions, with only a 10% loss of volatile substances, such as the lower alcohols, acids and ketones, together with the oxides of carbon and water.

A temperature range of 160° to 180°C. is employed, the paraffin being either maintained at the temperature in an autoclave subjected to an oxygen pressure of a few atmospheres, or it is heated in an air current for prolonged periods. Much uncertainty exists as to the value of different catalytic agents; according to some observers the salts, such as cobalt and manganese sterate, are most effective; other observers suggest stearic acid, and condemn all traces of alkali, and yet others find alkalies most effective. It would appear that the reaction is more complicated than a process of oxidation, and it is probable that a preliminary dehydrogenating action occurs.

$$CH_3\,(CH_2)_m\,CH_2\,CH_3 = CH_3\,(CH_2)_m$$
$$—CH\,CH_2 + H_2$$

followed by a direct addition of oxygen to form a peroxide

$$CH_3\,(CH_2)_n\,CH = CH_2\,CH_3\,(CH_2)_n$$
$$\begin{array}{l} —CH — CH_2 \\ \;\;\;\;| \;\;\;\;\;\;\;\;\; | \\ \;\;\;\;O——O \end{array}$$

from which the alcohols and acids are produced.

As typical of the results already achieved, Grün obtained a wax of the following characteristics : for comparison, the same data for beeswax are appended :—

	Synthetic wax.	Bees-wax.
Acid No.	21.0	20
Saponification No.	75.6	95
Iodine No.	4.7	9
Ratio No. $\frac{\text{Sapon-acid}}{\text{acid}}$ ..	3.6	3.7

Processes of Selective Oxidation.

In the absence of any catalytic material, the rates of reaction of two side reactions of the type $A + B \rightarrow C$ at any definite
$A + D \rightarrow E$
temperature, is constant. It is a point of active interest whether, on the addition of a catalytic material to the reacting system, both reaction velocities are equally accelerated or whether any selective action takes place. It has already been indicated that poisons in heterogeneous catalysis apparently functioned by means of selective adsorption. If this point of view be correct, selective action in a side reaction due to selective adsorption of one of the reactants should occur. Though it is to be anticipated that with change of catalytic material involving a change in the adsorption concentrations of the reactants at the surface, there should be a corresponding change in the relative rates of the two reactions. The earlier experiments of Henry, Turner and Hempel on the selective combustion of gases, have confirmed these generalisations. It has been found possible in a mixture of hydrogen methane and oxygen to burn all the hydrogen without affecting the methane at the surface of hot palladium. More recently, Bone has shown that at the surface of boro silicate glass beads the methane burns preferentially to the hydrogen.

Industrially, two processes of selective oxidation have been developed, the method being employed for the preparation of formaldehyde from methyl alcohol and for the removal of small quantities of carbon monoxide from hydrogen.

The production of formaldehyde by the oxidation of methyl alcohol dates from the time of Hofman (1878), who obtained a small conversion by the passage of an air alcohol mixture through a red hot platinum tube.

Of recent years, the demand for formaldehyde, largely utilised for the production of phenol-condensation products, the artificial ebonites in tanning processes and hide disinfection, has greatly increased, and numerous investigators have attempted to improve upon the somewhat crude methods employed in the earlier processes. The first point of interest which resulted from this work was that the formaldehyde is not produced by the partial oxidation of methyl alcohol but by a primary dehydrogenating action

$$CH_3\ OH = HCHO + H_2$$

the hydrogen being subsequently removed by oxidation to water at the surface of the catalyst. We have thus an interesting case of selective oxidation since but a small quantity of the formaldehyde is oxidised to carbon dioxide and water when suitable catalytic material is employed. It is evident that the use of a dehydrogenating catalyst would permit of the formation of formaldehyde without the addition of oxygen, but it is found that at the high temperatures necessary, viz., 300°C. destruction of the highly reactive formaldehyde ensues, and the catalyst becomes poisoned. Thus the ideal catalyst should exert a dehydrogenating as well as a preferential oxidising action on the hydrogen. Palladium or platinum which possess both these features are too highly reactive, but silver coated with a very thin film of platinum appears to be an ideal catalyst, a yield of over 95 % being claimed. In commercial practice at the present time copper is usually employed, a relic of the earlier investigations of Tollens and Trillat. The yield, however, rarely exceeds 60 %.

As instances of the variation in yield with the nature of the catalyst, the following figures (Fokin and Hochstetter) may be cited :—

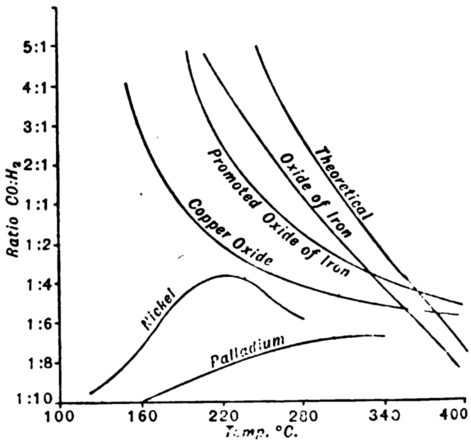
Metal.	% yield.
Ni.	1.08
Pt.	5.20
Cu.	55
Ag.	70
Ag. alloy	84
Ag. coated with 1/10,000 Pd. or Pt.	96

For the removal of small traces of carbon monoxide from hydrogen, the process of selective catalytic combustion has been elaborated and developed on technical lines, and shown to be a rapid and effective method of removing this gas from hydrogen intended for catalytic purposes.

If a small quantity of oxygen be added to such a gas mixture, it is evident that two reactions may occur

$$2H_2 + O_2 = 2H_2O$$
$$2CO + O_2 = 2CO_2$$

The rate which these reactions occur in a gas mixture in which the partial pressures of the reactants are kept constant is influenced both by the temperature employed and by the nature of the catalytic material, as is evidenced by the following curves :—

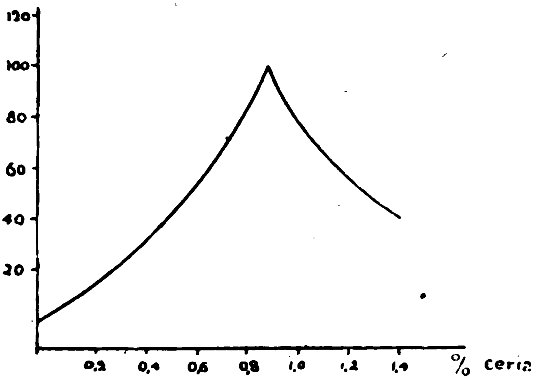


It will be noted that with both copper oxide and iron oxide at relatively low temperatures the ratio of CO to H_2 burnt is extremely high. Hydrogen manufactured by the steam iron process may contain from 0.2 to 0.5 % of carbon monoxide and for all catalytic processes it is desirable —and in some processes essential—to remove this impurity. The utilisation of suitable catalytic materials, *e.g.*, active iron oxide, copper oxide or manganese and copper oxide, evidently provides an easy and effective method for removing this impurity; owing to the strongly exothermic nature of the combustion process and the relatively low temperatures at which the catalysts are active the process is an autothermal one. Consequently, the cost is extremely low.

Catalysis in the Gas Industries.

The growth of catalytic processes in the gas industry has been relatively slow,

not so much on account of lack of appreciation of the possibilities inherent in the methods, but rather from the fact that scientific research in the gas world is comparatively recent, and that the extraordinary complexity of the reactions occurring during the coking of coal, and even in the manufacture of water gas, a much simpler operation, have made investigation extremely difficult. In certain directions, however, an advance has been made, and there appears little doubt that with increasing knowledge progress will be even more rapid. Possibly the oldest catalytic process of technical value to the gas industry was the discovery of the incandescent mantle. The light emissivity from a thoria mantle is relatively feeble, as is also the case with a mantle of ceria. On the other hand, a mantle of thoria containing 0.9 % of ceria gives the brilliant light with which we are all familiar. The variation in light emissivity under constant conditions with variation in the ceria content is depicted in the following curve.



Spectroscopic examination of the emission spectra of the mantles indicates that both the thoria and the ceria exert a selective emission, and consequently the mantles are at a somewhat higher temperature than a black body radiation with the same gas consumption. The ceria mantle is particularly rich in light at the red end of the spectrum and the thoria at the green and violet. The addition of a small quantity of ceria to the thoria mantle consequently admits of the formation of a spectrum over the whole range of visibility.

In addition, it appears probable that the catalytic action of the ceria accelerating the combustion of gas is at a maximum at 0.8 %, with the result that the gas is burnt at the surface and not away from it. Under these conditions, the thoria is raised to the highest possible temperature obtainable with the fuel employed. In lieu of ceria, other promoters may be utilised, such as vanadium manganese and uranium oxides, all polyvalent elements, indicating the possibility of the formation of a daylight mantle.

At the hands of Bone and Schnabel the principles of surface combustion have also been developed for the heating of furnaces. At high temperatures, all surfaces appear to be equally active as catalytic agents in promoting the oxidation of gaseous fuels; thus by passing an air gas moisture through a porous fire brick diaphragm, the brick could be maintained at very high temperatures, and complete combustion of the fuel effected in a very thin layer $\frac{1}{8}$ to $\frac{1}{4}''$. A highly efficient radiator is thus produced, and tests on boilers and metal melters fitted with such surface combustion heaters have indicated a remarkable thermal efficiency. There are, however, numerous practical difficulties associated with the method apart from the possibilities of a serious explosion occurring in a strike back. The diaphragm, if fine pored, is rapidly blocked up by silica oxide of iron and other dust in the gas or air; if coarse, refractory material be employed to suit technical conditions, a sacrifice of the principle of surface combustion has to be made, with a consequent lowering of efficiency.

Not only in the utilisation of gaseous fuels, but also with their production and purification, applications of catalytic methods are to be noted.

In the production of gaseous fuels recent legislation has opened the way to a fuller utilisation of catalytic processes. It is proposed that gas shall be sold on the therm instead of the cubic foot basis, and at the present time committees are sitting to discuss the limitation of the carbon monoxide and inert content of public gas.

It is generally recognised that even if the regulation of a therm basis becomes general, blue water gas has too low a calorific value for household use. The actual therm value of the gas produced in a gas-work must, of course, vary with the market for by-products, the cost of manufacture of the gas, and the overhead charges in plant upkeep. The therm output of a plant of a given size may be very different from the cubic feet obtainable.

The problem of converting blue water gas into a gas of a higher calorific value by methods other than the method of carburation with oil, or the more recent method of carburation with coal gas in the continuous retort, has attracted a number of investigators, and several alternative proposals have been suggested. The conversion of carbon monoxide into methane by hydrogenation, occurs rapidly

$$CO + 3H_2 \rightarrow CH_4 + H_2O$$

at the surface of reduced nickel under suitable conditions, of which the most important are that the H_2 : CO ratio must be at least 5 : 1, and the gas perfectly free from catalytic poisons, especially sulphur compounds. Since water gas contains H_2 : CO in the ratio of 1 : 1 it is evident that partial removal of the carbon monoxide or addition of supplementary hydrogen must be provided. The former is readily accomplished by liquefaction, a process which possesses the great merit of simultaneously removing all the catalytic poisons.

By the adoption of the liquefaction process to water gas with a fractional removal of the carbon monoxide and subsequent hydrogenation, it was found possible to raise the calorific value per cubic foot from 288 to 490.

An alternative process elaborated by Sabatier was to utilise low temperature water gas in which, after removal of the carbon dioxide, a high hydrogen carbon monoxide ratio is obtained. Yet a third method would suggest the manufacture of hydrogen by the catalytic method or steam iron process with part of the water gas, followed by admixture with the rest of the water gas before hydrogenation.

A number of experiments were likewise conducted by Sabatier on the catalytic decomposition of carbon monoxide at high temperatures at the surface of hot nickel.

$$2CO = C + CO_2$$

The carbon is deposited in a highly reactive form, so reactive that it readily combines with steam to form methane and carbon dioxide.

$$2C + 2\,H_2O = CH_4 + CO_2$$

Nevertheless, in spite of these several attempts, no technical development is to be recorded.

In addition to the problem of carbon monoxide, that of sulphur is of great interest. The catalytic influence of both moisture and sunlight on the oxidation of the sulphur dioxide produced by an incandescent mantle utilising a sulphur containing gas can readily be demonstrated by determination of the oxygen absorbed from permanganate of air samples in confined spaces. Hydrogen sulphide, present in the original gas, is readily removed by iron oxide, but organic sulphur compounds, such as carbon disulphide, thiophene and more complex compounds, are not affected by this treatment. Attempts to effect their removal by catalytic methods have been made in two directions, catalytic decomposition and hydrogenation at the surface of hot nickel, a process in use at the South Metropolitan Gas Works, and catalytic hydrolysis at the surface of oxides, such as iron, manganese and aluminium, a process found feasible on a small scale. These two reactions may be represented formally by the equations

$$(1)\quad CS_2 + 2H_2 = C + 2H_2S.$$
$$(2)\quad CS_2 + 2H_2O = CO_2 + 2H_2S.$$

The selective and fractional combustion of sulphur compounds at the surface of oxide catalysts, as well as in the presence of certain hydroxides, proceeds smoothly in the case of hydrogen, but in the case of coal gas the presence of easily absorbable unsaturated hydrocarbons interferes with the reaction.

$$2H_2S + O_2 = 2H_2O + 2S$$
$$CS_2 + O_2 = CO_2 + 2S$$

Atmospheric oxidation in solution has likewise been attempted with colloidal solutions of ferric hydroxide as absorbent. It would appear possible to make this process continuous and catalytic by the utilisation of a more active metal than iron, e.g., nickel sulphide, which undergoes oxidation with great ease. Promotion of the reaction might be accelerated by the addition of other catalytic agents, such as cerium, vanadium, or even copper salts, to the solution.

Owing to the shortage of liquid fuels derived from oil, the increased production of another fuel in the gas industries will be watched with interest. Hexahydrobenzene produced by the catalytic hydrogenation of benzene which, somewhat curiously, commands a better price as gas at the present time than as a fuel, at the surface of carefully reduced nickel, and ethyl alcohol produced by the catalytic hydrolysis of ethylene, are promising developments. The former has already proved

of inestimable value for airplane work on account of its uniformity of composition, but the production of the latter cannot yet be said to be on an industrial basis, owing to the fact that as long as sulphuric acid is employed as absorbent and catalytic agent, the cost of the cyclic evaporating and concentration necessary is practically prohibitive. Hydrogenated naphthalenes have been employed it is claimed with success as lubricants. The fractional oxidation of this aromatic hydrocarbon has already been referred to. Renewed attention is being paid to the influence of catalytic agents in the complex cases of hydrogenation and dehydrogenation occurring during the coking of coal and in the distillation of tars.

The preliminary chemical reaction in the retorting of a dry coal is probably one of dissociation of the coal complex into saturated rings, such as hydronaphthalene and hydrobenzene. At 250°C.—350°C. the dehydrogenation of the saturated ring compounds commences, *e.g.*,

$$C_6H_{12} \rightarrow C_6H_6 + 3H_2$$

The yields of the various constituents in the first operation depends almost entirely on the nature of the coal; those in the second reaction, which is variable in character are chiefly determined by the nature of the atmosphere in which the gasification is accomplished. From 350°—500°C. reactions of the type of Friedel and Craft, *e.g.*,

$$2C_6H_6 \rightarrow C_6H_5\,C_6H_5 + H_2$$

are of supreme importance. The catalytic influence, both of the retort walls and of the various constituents of the coal "ash" is probably of importance at this stage of the process.

At still higher temperatures, fracture of the ring in cyclic hydrocarbons with the formation of aliphatic hydrocarbon chains occurs, which, as the temperature rises, undergo chemical disintegration with the formation of both saturated and unsaturated hydrocarbons, until at ca. 1200°C. complete decomposition into hydrogen and carbon occurs, incandescent carbon being the catalytically active material. With oxygen containing coals, more especially the lignites, the presence of carbon monoxide in the gas can already be demonstrated at low temperatures. Oxygen once absorbed on the surface of carbon can never be removed as such. Interaction between carbon monoxide and steam results in the attainment of the water gas equilibrium within the retort, a reaction for which most diverse substances may act as catalytic materials at high temperatures, whilst the iron oxide in the ash of the coal is most active below 700°C.

In the absence of oxygen, the process of coal cracking would appear to be an endothermic reaction, with increasing quantity of this constituent, the endothermating sinks and the reaction finally becomes exothermic.

Much work of an investigatory nature has still to be accomplished in order to ascertain how far the operation of retorting may be divided into distinct phases of the kind outlined above. Experimental data obtained are always subject to the criticisms that too rapid heating of the material may have occurred, retorts being usually fired at 1200-1300°C.; that no provision for the presence of catalytic materials was ensured, and superheating of part of the material, especially the gases on the retort walls, had taken place.

The problem is an important one, since the complete destruction of the intermediates results, not only in the loss of substances possessing in many cases a potential value higher than that obtainable as a carburetting agent for gaseous fuels, but in a very great diminution in the thermal value of the fuel produced.

LECTURE III.—*Delivered February 28th,* 1921.

PROCESSES OF HYDROGENATION.

HYDROGEN MANUFACTURE.

The recent growth in the consumption of hydrogen for diverse industrial purposes, *e.g.*, filling rigid airships, synthesis of ammonia, oil hardening and the fine chemical industry, has stimulated research in the methods for the manufacture of hydrogen more economical than the steam-iron process which holds the field to-day. A certain measure of success has already attended these investigations, and it is interesting to note that catalytic methods are utilised. One which has already passed the experimental stage and is that generally employed in the synthesis of ammonia is the water gas catalytic process. This process, originally English, but developed in Germany just prior to the war, is based upon the fact that the reaction $CO + H_2O = CO_2 + H_2 + 10{,}100$ cals is reversible and slightly exothermic

thus by the interaction of water gas and steam at low temperatures it should be possible to effect the conversion of the carbon monoxide in the water gas into carbon dioxide and hydrogen. As the temperature sinks, however, catalysts must be employed to accelerate the reaction velocity. Unfortunately, we know of no catalyst which will operate under industrial conditions at temperatures below 400° C., where with a slight excess of steam the reaction would proceed so far as to yield a gas containing negligible quantities of carbon monoxide.

As most effective catalysts oxide of iron admixed with one or more promoters is generally employed: thus chromium oxide manganese oxide, copper oxide, cerium oxide are all promoters finding industrial application. Generally one volume of water gas to 2½ volumes of steam is employed, the reaction mixture is passed through a series of heat interchangers and then through the converter containing the catalytic material deposited on trays, so as to prevent crushing of the catalyst and to assure an even temperature distribution, the whole being maintained at 500° C.

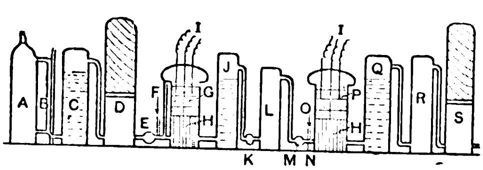
The following is an average analysis of the water gas and the converted gas after the removal of the excess steam :—

Water Gas.	Converted Gas.
H_2 49	H_2 64
CO 43	CO 2
CO_2 3	CO_2 30
N_2CH_4 5	N_2CH_4 3.8

Purification of gas thus produced is effected by pressure scrubbing with water to remove the carbon dioxide, whilst the residue of the carbon monoxide is removed by pressure scrubbing with cuprous ammonium salts or by a process of fractional combustion.

It is important to note that this gas is unsuitable for many purposes owing to the presence of the relatively large quantities of nitrogen derived from the water gas.

The general diagramatic lay out of such a plant is as follows :—



A. W.g. generator. B. Preheater. C. W.g. scrubber. D. W.g. gasholder. E. Booster. F. Steam inlet. G. Catalyst box. H. Heat interchanger. J. Condenser. K. Pump L. Pressure scrubber. M. Release valve. N. Steam inlet. O. Oxygen inlet. P. Catalyst for combustion of CO. Q. Condenser. R. Scrubber. S. Hydrogen gas holder.

Except in the case of very large plants, *e.g.*, 20,000 c. ft. per hour, the loss by radiation exceeds that supplied by the reaction and additional heat has to be supplied to maintain the temperature. If a catalyst operative at from 350° C. to 400° C. could be prepared, many of the difficulties inherent in this type of plant would be removed.

Another interesting development in hydrogen manufacture is found in the Bergius process where coke or coal is caused to react with water at a temperature of 300° C. under a pressure of some 90 atmospheres. This is in reality effecting the water gas plant reactions at low temperatures.

$$C + H_2O = CO + H_2$$
$$CO + H_2O = CO_2 + H_2$$

Small bombs are employed containing broken coal and water which are heated externally up to 300°C. and the hydrogen and carbon dioxide removed through a pressure valve. These reactions will, naturally, only take place in the presence of catalytic agents ; as such, thallium salts and halides have proved themselves extraordinarily effective. Hydrogen in a high state of purity is produced by this method and conveniently under pressure. The chief disadvantage of the process as at present developed is its discontinuity in operation. Since, however, an autoclave of only 1.5 cubic feet of capacity will hold a charge sufficient for 1,500 cubic feet of hydrogen, and this quantity of hydrogen should be attainable from only 12 kgm. or one quarter of coke, the process is worthy of serious attention.

The reaction velocity of the process appears to be governed by the first heterogeneous reaction $C + H_2O = CO + H_2$. To accelerate this reaction an extended solid phase is required which would probably be most conveniently attained by grinding the coke to a fine powder.

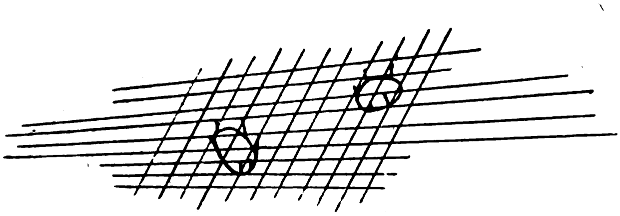
Amongst the more important recent developments in processes of catalytic hydrogenation, I should like to refer briefly to three, the production of hexa-hydrobenzene, the hydrogenation of unsaturated oils and the manufacture of synthetic ammonia. England is entirely dependent on foreign sources of supply for fuel for its internal combustion

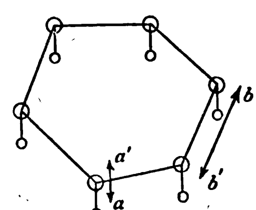
engines, the home oil wells at present supplying but an infinitesimal amount towards our annual consumption. As a substitute for foreign petrol we naturally turn to possible sources at home. The Government Committee appointed to investigate this problem have reported favourably on benzene alcohol mixtures as a fuel. The benzene is already available in limited amounts being recovered in many of the industries engaged in the carbonisation of coal. That removal of the benzene from all coal carbonised in large plants in England is not made compulsory is probably due to the fact that in the process of stripping illuminating gas its calorific value is reduced to an exceedingly low figure; the new legislation authorising the sale of gas on the therm basis will permit of benzol recovery if desirable from a financial point of view. Benzene itself is, however, by no means an ideal fuel for internal combustion engines, it has a high freezing point and the carbon hydrogen ratio is too high, and for this reason it is suggested that admixture of alcohol would prove beneficial. The production of alcohol on a large scale at fuel costs has not yet been developed, and a considerable period of time may elapse before coal-alcohol produced by the catalytic hydration of ethylene recovered from fuel gases becomes a regular item on the liquid fuel market. On the other hand, it is possible to improve benzene as far as its calorific value and carbon hydrogen ratio are concerned by hydrogenation according to the reaction

$$C_6H_6 + 3H_2 = C_6H_{12}$$

Such a fuel hexahydrobenzene is very similar to petrol in its general characteristics and is superior to it in uniformity, since petrol consists of a number of hydrocarbons of different boiling points. For airplane motors which have frequently to operate under low atmospheric pressures, this item is of great significance. In the United States hexahydrobenzene has been frequently used for airplane work in preference to petrol. Hydrogenation is readily accomplished by the passage of hydrogen through benzene scrubbers maintained at a suitable temperature to ensure the correct ratio of benzene to hydrogen in the effluent gas. As catalytic material palladium asbestos or nickel deposited on diatomaceous brick is employed, placed in long steel tubes which are externally heated to a temperature of 90°-140° C. The products are condensed in a fractionating column, the benzene returned to the benzene scrubbers and the effluent hydrogen to the hydrogen gasometers. Provided that the benzene has been previously purified from thiophene the process operates smoothly and continuously.

Of great scientific interest is the fact that at low temperatures only hexahydrobenzene is produced with no dihydro or tetrahydro product. This curious fact is capable of explanation on the hypothesis which is supported by experimental data from measurements of the surface tention of benzene and aromatic derivatives on water that the benzene molecule lies flat upon the catalytic materials. The thickness of a benzene molecule is 1.19×10^{-8} cm. thick, and the distance between adjacent carbon atoms some ca 6.2×10^{-8} cm., the absorbed benzene molecule would thus present somewhat the following appearance, from which the mechanism of the reaction is apparent :—





$aa' = 1{\cdot}19\ 10^{-8}$cm.
$bb' = 6{\cdot}2\ 10^{-8}$cm.

Attempts are now in progress to produce suitable lubricating oils and greases by the catalytic hydrogenation of the higher unsaturated hydrocarbons such as naphthalene and anthracene.

The Hydrogenation of Unsaturated Oils.

During the last ten years many factors have stimulated the production of hardened oils, amongst which the shortage of animal fats occasioned by the war, the systematic development of plantations of oil-bearing

seeds or nuts, the economic stress in cotton and soya bean industries, as well as the oceanographic work on the distribution of certain fish, more especially the whales. The conversion of a liquid glyceride into a partly solid lard substitute or a solid margarine and to a lesser extent the production of saturated fatty acids for soap making purposes, are now well-established industries. It will readily be appreciated that the economics of a fat hardening factory are extremely complicated owing to the fluctuation in price of the various possible raw materials and the competition of the natural animal fats, produced both from milk and from the slaughter house. Sabatier and Senderens paved the way for the industry by showing that nickel was an effective catalytic agent for the hydrogenation of the vapours of the unsaturated fatty acids; the method, however, possessed but little economic value owing to the fact that thermal decomposition of the acids and glycerides occurs when vaporised at high temperatures, unless very low pressures are employed. Two years later the patents of Leprince and Siedeke in Germany, and of Normann in England, disclosed the fact that hydrogenation could be effected with the liquid glyceride when suitably prepared nickel was employed, the basis of the methods in use to-day. Owing to the fact that solution of the hydrogen in the oil prior to reaction must take place, increase of pressure augments the reaction velocity, as is observable from the following figures of Shaw:—

Pressure in atmospheres at 250°C	Iodine No. after identical time intervals.
5	77
25	64
50	52

There is consequently in modern plants a tendency to employ hydrogen under pressure, whilst the older plants operated under but a slight head.

The preparation of an active catalyst is of paramount importance, and the patent literature on this subject is now extremely large. It may be noted that utilisation of other metals in addition to nickel, such as palladium and platinum, in operation at one time is for economic reasons alone not seriously to be contemplated. The catalytic material is usually prepared by precipitation of nickel carbonate and reduction at low temperatures in a current of hydrogen at a low temperature, preferably below 300° C.; the reduced metal is then suspended in the oil, which is raised to 180°-200° C. and agitated with hydrogen with or without the assistance of mechanical stirrers, the course of the reaction being most conveniently followed by determination of the refractive index of the oil. It is found essential to maintain the temperature as low as possible so as to avoid imparting a flavour and colour to the material, both extremely difficult to remove with steam and Fuller's earth. Since the reaction itself is exothermic, the rate of hydrogenation must be carefully controlled. Generally, however, nickel, when prepared from the carbonate, is not sufficiently active, and attempts have been made to improve the material both in respect to catalytic activity, but more especially in its resistance to poisons. The chief poison in fat hydrogenation is sulphur. A very small quantity of organic sulphur compounds is present in the hydrogen derived from the steam-iron process and is not removed by the lime box, but by far the greater quantity is found in the oil itself, especially in soya bean and certain fish oils. For soya bean oils grown in a bad season a fresh batch of catalyst has frequently to be made for each new kettle of oil. Carbon monoxide present in the hydrogen and the unsaturated lighter hydrocarbons, aldehydes, alcohols and acids always present in the oil or formed during the process of hydrogenation at the somewhat elevated temperature of 180° C. are objectionable, owing to the fact that their absorption co-efficients on nickel are far higher than that of hydrogen resulting in an apparent poisoning of the catalyst. At higher temperatures, however, ca 250°-300° C., these are desorbed again, and catalysis proceeds, although, as has already been noted, rather to the physical detriment of the oil if intended for edible purposes. Most of the attempts to enhance catalytic activity of the nickel are based upon the reduction of a nickel salt, *e.g.*, a carbonate, formate or acetate in the oil, or some suitable liquid vehicle; in this way two purposes are accomplished, the reduced metal is entirely protected from re-oxidation, and by reduction in a suitable oil peptisation of the nickel during reduction is assisted, resulting in high dispersion of the metal with a consequent augmentation of the surface area. Lessing achieves a high dispersivity by the solution of nickel carbonyl in the oil with subsequent thermal decom-

position. Opinion at present is somewhat at variance as to whether a very high dispersivity is really necessary; according to several independent investigators it would appear that atomic dispersion is not desirable, but rather a small nucleus of possibly adherent unreduced oxide coated with active nickel is most effective. It would appear plausible to assume that since hydrogen is not very soluble in the oil most rapid hydrogenation is effected if provision is made for an enormous number of small hydrogen reservoirs distributed through the oil. Now finely dispersed nickel cannot act as a reservoir for free molecular hydrogen, although it may function perfectly for adsorbed hydrogen, unless it can readily form a small bubble of this gas in and around the nickel particle. If the particle be very small, then owing to the effect of surface tension there would be an excess pressure inside the bubble, and consequently the conditions for small bubble formation are not favourable. If the surface tension of hot oil be taken as 40 dynes per square centimetre, then with a colloidal nickel particle 5 μ in diameter, so large, in fact, that Brownian motion has just ceased, *i.e.*, the largest particle that can be retained indefinitely in suspension in the oil, the excess pressure will be some 0.16 atmospheres. A smaller grain size is only compatible with a lower interfacial surface tension of the oil, *i.e.*, a higher temperature.

Recently the utilisation of promoted catalysts is making its appearance in the oil hardening industries, as promoters the metals copper and silver are extremely effective, but extreme care and attention to detail are even more requisite in the preparation of these than in the unpromoted varieties.

THE SYNTHESIS OF AMMONIA.

Of all the purposes to which hydrogen may be applied, the synthesis of ammonia is by far the most important.

In 1884 Ramsay and Young showed that ammonia was formed by the passage of a mixture of nitrogen and hydrogen over heated iron wires; later, in 1901, Le Chatelier pointed out the importance of using the gases under pressure owing to the great change in volume occurring during the reaction

$$3\ H_2 + N_2 = NH_3 + 11{,}000\ \text{cal.}$$

Finally, in 1904, Haber and his co-workers commenced their investigations, culminating in the large factories erected by the Badische Anilin u. Soda Fabrik at Oppau and elsewhere, which started successful industrial operations during the early stages of the War. It may be safely stated that the Haber ammonia process is the greatest triumph yet effected by applied physical chemistry.

The enormous effect of pressure on the equilibrium concentrations of the above reactions is readily observable from the following figures:—

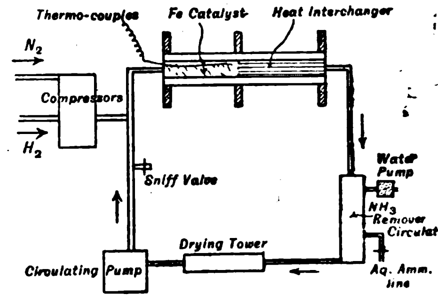
	% NH_3 at		
Temp.	1 atm.	100 atms.	200 atms.
300	2.18	52.1	62.8
400	0.44	25.1	36.3
500	0.129	10.4	17.6
600	0.044	4.47	8.25

The effect of high pressures and low temperatures in promoting ammonia formation is clearly demonstrated. A search for suitable catalytic materials, however, revealed the fact that with the exception of uranium carbide and osmium no substitute—the former too sensitive to poisons and the other too expensive—possessed very marked catalytic activity below 500°-600° C., and at the present time a low temperature ammonia catalyst is most urgently needed. It was at once realised that on the technical scale high pressures and, unfortunately, somewhat high temperatures would have to be employed implying also a small fractional conversion on passage through the catalyst, thus indicating a circulatory process of operation.

The following is a brief outline of the modern synthetic ammonia plant:—As raw material coke is employed in water gas generators for the production of a high-grade blue water gas, for steam raising and operating a liquid air fractionation plant, from whence the nitrogen is derived. The blue water gas admixed with nearly three times its volume of steam is passed through the water gas converters at a temperature of 500°-550° C., where the water gas equilibrium is attained with the aid of oxide of iron admixed with suitable promoters as catalytic agent. After condensation and the removal of the excess of steam, the carbon dioxide and hydrogen sulphide are removed by pressure scrubbing with water at 20 atmospheres. The residual gas, consisting of nearly pure hydrogen admixed with some 2-3 % of carbon monoxide small quantities of nitrogen, methane and carbon dioxide and traces of sulphur compounds, is passed

on to the carbon monoxide removal plant. Pressure scrubbing with a solution of cuprous ammonium carbonate or formate has been generally employed, but it would appear that the process of selective combustion now operative on a large scale would prove much more economical than removal by pressure scrubbing. Admixture of nitrogen from which all oxygen has been removed by passage over hot reduced copper turnings provides the nitrogen hydrogen mixture with which catalysis is effected. It will be noted that small quantities of methane from the hydrogen and rare gases from the nitrogen act as inerts in the system, the ultimate disposal of which is apt to cause a serious gas loss. The last traces of impurities, such as carbon monoxide or sulphur compounds, are removed by passage over reduced nickel maintained at 180° C., followed by some suitable drying agent, either before or after the gases are compressed to the operating pressure of 200 atmospheres in the case of the Haber, or 1,000 atmospheres in the case of the more recently developed Claude plant. The Haber bomb unit consists of a long steel tube of two sections, each 6 metres long, 80 cm. internal diameter and 18 cm. thick, lined with a magnesia heat insulating material and provided with a space for catalytic material and for heat interchange system. As catalytic material relatively coarse grained reduced iron is employed, the iron being prepared with the addition of a small quantity of alkali as promoting agent.

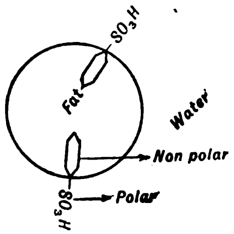
In England iron molybdenum mixtures were originally employed, but the granules prepared from this material could not withstand a high crushing pressure. The optimum flow rate of the gas mixture through the catalyst mass is dependent, as we have noted in our first lecture, on a number of varied conditions, the chief factor, however, limiting the space time yield being in this case the efficiency of the heat exchange system. The effluent gases containing some 3-8 % of ammonia, depending on the activity of the catalyst, are passed through a small pressure water scrubber, the ammonia removed and the gas mixture passed round through the catalyst *de novo*. In the Claude process a much higher yield of ammonia, up to 20 %, is obtained owing to the increased pressure, and this is removed in the liquid forms through a small separating tower. For the removal of the inerts a 10 %-15 % blow off is required; frequently, however, this loss is obtained through leakage in the system.



Opinion at the present time is rather sharply divided on the most suitable type of bomb for the synthesis. The simplest type is one in which the bomb consists of two portions, one a catalyst chamber and the other a simple direct flow heat interchange system. The thin insulating lining is generally insufficient to keep the metal itself down to a low temperature. Tho type developed in Germany may be termed the hot bomb type. It has the merits of simplicity of construction alone in its favour. Its thermal efficiency is but low, air having frequently to be admitted to maintain the temperature and the gas flow rate and space time yield being very poor. Attempts have been made to develop a cold bomb, in which the catalyst chamber is surrounded by a series of progressive heat interchangers, which permits of much higher thermal efficiencies, and owing to the autothermal nature of the reaction under these conditions a higher yield per space time unit is possible. On the other hand, to take full advantage of the increased efficiency of this type of bomb the more difficult engineering problems have to be solved and the loss of head in the gas system between inflow and outflow of the bomb becomes an important factor in the economics of the process.

In our first lecture we discussed the problem of ester hydrolysis utilising acids as catalytic agents, and mentioned the important applications of the method to wood cellulose and the sugars. Interest in the hydrolysis of fats by means of the Twitchell reagent has been renewed with the development of the concept of molecular orientation. The process of operation of the Twitchell reagent can readily be grasped when we recollect that at the interface of

an emulsion of fat in water, the catalyst to be effective in emulsification must lower the interfacial surface tension. It is clearly evident that most effective as catalytic agencies will be those substances the molecules of which have both strongly polar or water soluble and strongly non-polar or fat soluble components. In consonance with this hypothesis the sulphonic acids of both the aromatic and higher aliphatic hydrocarbons are found to be catalytically active.



Another interesting process of catalytic hydration is involved in the manufacture of alcohol, which we have already mentioned. To illustrate the remarkable utility of catalytic methods in these and similar processes in organic chemistry, the following diagram illustrates a series of processes actually in operation during the period of the war :—

Reaction $CaC_2 \rightarrow C_2H_2 + H_2O \rightarrow CH_3\ CHO + H_2 \rightarrow CH_3\ CH_2\ OH$ ($\uparrow$ $C_2H_5O\ C_2H_5$)

Catalyst Hg. salts in acetic acid. | Nickel or copper $+ O_2$ Manganese acetate in acetic acid. | H_2SO_4 and V_2O_5 | $C_2H_4 + H_2O$

$\downarrow$ $CH_3\ COOH \rightarrow CH_3\ CO.\ CH_3$
CaO

Mention might also be made of numerous other catalytic processes fostered by war conditions only to die when the normal economic life of the community re-asserts itself. One of the best examples of this type of industry was the synthetic rubber manufactured in Germany up to the period of peace. Rubbers are formed by the polymerisation of divinyl derivatives of which the most important is natural caoutchouc derived from methyl divinyl or isoprene $CH_2 : C(CH_3).\ CH : CH_2$. Polymerisation may be effected by a number of catalytic agents as varied as acetic acid and metallic sodium. From the industrial point of view, however, the process has but little interest since the rubber trade can effect the synthesis of the complete rubber under favourable conditions in the Malay States and other tropical climates at a cost which is far less than that entailed in the production of isoprene itself. In the case of synthetic indigo, the artificial products possessed advantages over the natural in respect to uniformity, and the indigo plant itself was not a very efficient one for the production of the colouring matter. With rubber on the other hand, the conditions are the converse; the tree is an efficient rubber factory and the natural product is superior to the artificial. The production of cheap synthetic rubber is just possible if a paraffin or other commercial hydrocarbon is utilised as raw material, and experiments in this direction have indicated the possibilities of such a method.

In the vulcanisation of rubber, on the other hand, the employment of catalysts to accelerate the interaction between the colloid rubber and sulphur or sulphur compounds is now universal. The action of these catalytic materials is not fully understood. Feebly basic materials are generally catalytically active, and the oxides of calcium magnesium and lead are the most common of the inorganic accelerators. In the aliphatic series the salts of oleic acid and the alkyls of lead and mercury are said to be effective, whilst most powerful are piperidine p. phentidine, p. aminophenetol aniline and quinine. It would appear that a hydrocarbon soluble or non-polar grouping associated with a group capable of reacting with sulphur is desirable in this class of catalytic agent.

In conclusion, it is to be hoped that with the after-war demand for increased economic production on the one hand, coupled on the other with increased leisure and happier conditions for the operation, the utility of the catalyst to solve this paradoxical

problem will be recognised, and that as a result both English science and English industry will again take the lead in friendly rivalry amongst the nations.

ALSATIAN POTASH INDUSTRY.

Potash was discovered in Alsace in 1904 while prospecting was being carried on for coal and petroleum. Borings were first made to a depth of 984 feet. No traces of coal or petroleum being found, borings were continued, and at a depth of 1,919 feet salt of potash of an excellent quality was discovered.

The Alsatian potash deposits extend between Mulhouse, Cernay, Soultz, and Ensisheim, with a total area of 124 square miles, and an average thickness estimated at about 14 feet 9 inches, with a calculated tonnage of 1,472,000,000 metric tons of salts containing 300,000,000 metric tons of potassium oxide (K_2O).

The deposits are about 14 miles in length, and about 6 miles in width, east to west. The basin has been affected by the formation of the Rhine Valley, and it is thought to be a result of the lagoon state of the region during the Oligocene period.

The potash layers extend in the centre of a salt formation in two parallel layers, the upper one being 1 foot 3 inches to 3 feet 9 inches thick, averaging in potassium oxide about 25 per cent., and the other one 65 feet deeper, 11.4 to 13 feet thick, averaging from 17 to 25 per cent. of potassium oxide. The upper layer is irregular on the borders east and west, whereas the lower layer is regular. The potash layers are found at a depth of from 656 to 2,296 feet.

Borings revealed the following earth composition:—

	Thickness in feet.
Sand and gravel	131
Clay, etc.	656-1,640
First salt deposit containing the two potash layers	721
Clay, etc.	328
Second salt deposit without potash	656-820

At the time of the signing of the Armistice, the amount of the capital invested was about £3,500,000, and was divided as follows:—German and Alsatian Government capital, 55 per cent.; French capital, 25 per cent.; Alsatian capital, 20 per cent.

At the present time, writes the U.S. Consul at Paris, with the exception of the Kali Ste-Thérèse French company, which is working the Bollwiller and Ensisheim mines, the Alsatian potash mines are under the administration of a sequestration committee, which resumed the exploitation and sales through the Bureau de Vente de Mulhouse, now known as the Société Commerciale des Potasses d'Alsace.

The Alsatian potash layer is found to contain sylvinite, which is a mixture of potassium chloride and sodium chloride. The analysis of the French Bureau of Mines shows the composition of the sylvinite extracted from the mines actually in operation to be as follows:—

	Per Cent.
Potassium chloride (corresponding to 19.80 per cent. K_2O)	31.30
Sodium chloride	56.00
Magnesium chloride	.35
Sulphate of lime	2.90
Insoluble matter	8.55
Humidity	.90

This analysis differs from the analysis of the German crude salts mined at Stassfurt before the War in the small amount of magnesium chloride, which is said to be detrimental to certain plants, such as sugar beets, potatoes, and tobacco. Alsatian potash has also the advantage of its smaller water-absorbing power, as it contains only 0.90 per cent. humidity, whereas the hartsalz contains 5 per cent., kainite 13 per cent., and cornallite 26 per cent. It is maintained that Alsatian salts stand long distance transportation and storage better than Stassfurt salts.

The average percentage of sylvine, practically pure potassium chloride, varies between 25 to 40 per cent. in the Alsatian salts, whereas it varies between 14 to 35 per cent. in the Stassfurt salts.

The production of Alsatian potash (crude salts) during the seven years 1913-19, has been as follows:—

	Metric Tons.
1913	355,341
1914	325,880
1915	114,358
1916	204,474
1917	320,131
1918	333,499
1919	592,000

During 1919 the quality and quantity of potash produced were as follows:—Sylvinite from 12 to 16 per cent. K_2O, 262,778 metric tons; sylvinite from 20 to 22 per cent. K_2O, 163,715 metric tons; and potassium chloride from 50 to 60 per cent., 38,112 metric tons.

Potash is used industrially, though it may often be replaced by soda. In 1895 the industrial use of potash took up about 50 per cent. of the total production. In 1913 it had decreased to about 10 per cent. Potassium chlorate is used in the manufacture of explosives; potassium bromide and potassium iodide are utilised in pharmaceutical products; potassium cyanide is used in galvanising and in the treatment of gold ore; and caustic potash in the making of soap and the extraction of grease from wool. Carbonate of potassium is used in the manufacture of glassware. In certain instances, such as in the manufacture of pottery, in photography, and printing, soda cannot be utilised in the place of potash.

But by far the most important use of potash is in agriculture. The following table shows the amount consumed in agriculture and industry respectively during a period of 18 years previous to 1914. Figures therein represent metric tons of pure potash (K_2O) :—

Years.	Consumption, in metric tons.		
	In agriculture.	In industry.	Total.
1895.........	119,103	50,556	169,659
1900.........	232,280	70,790	303,610
1905.........	407,161	76,107	483,268
1910.........	762,898	90,984	853,882
1913.........	1,003,913	106,456	1,110,369

The table following shows the consumption of potash fertilisers (in terms of kilos of potassium oxide) used per square kilometre on land under cultivation. (Square kilometre = 0.3861 square miles; kilo = 2.2 pounds.)

Countries.	1895.	1900.	1905.	1910.
	Kilos.	*Kilos.*	*Kilos.*	*Kilos.*
Germany ...	170.6	334.4	576.5	1,025.1
Belgium ...	152.8	191.3	495.6	476.6
Denmark ...	329.7	669.3	152.1	171.2
Netherlands	125.3	350.3	854.3	1,449.3
United Kingdom...	21.1	105.0	195.0	225.1
France	15.3	25.1	34.1	69.6

The following table shows the production of important crops in the above countries. It will be seen that the countries with the largest potash consumption were also the largest producers of cereals, etc. The figures therein represent production in metric tons per hectare (hectare = 2.471 acres).

Countries.	Wheat.	Rye.	Barley.
	Metric tons.	*Metric tons.*	*Metric tons.*
Germany	2.13	1.78	2.05
Belgium	2.50	2.21	2.73
Denmark	3.26	1.59	2.26
Netherlands	2.45	1.76	2.58
United Kingdom ...	2.11	1.88	1.87
France	1.29	1.02	1.39

Countries.	Oats.	Potatoes.	Sugar Beets.
	Metric tons.	*Metric tons.*	*Metric tons.*
Germany	1.94	13.58	28.56
Belgium	2.39	18.91	27.56
Denmark	1.83	15.42	30.39
Netherlands	2.06	14.53	31.56
United Kingdom	1.82	14.83	—
France	1.29	8.18	23.85

Of the 1919 production of pure potash (K_2O) in Alsace, amounting to 96,546 tons, France consumed 41,470 tons, 28,090 tons were shipped to the United States, and 5,690 tons were used in Alsace.

PROSPECTS OF WOOD-PULP PRODUCTION IN CHILE.

Those familiar with Chile's timber resources consider this an opportune time to invite attention to the possibility of developing a wood-pulp industry in the southern part of the country, where the islands and mainland are thickly forested. Hitherto it has been thought that the remoteness of these timber supplies would make their exploitation unprofitable until such time as more accessible wood-pulp material ceased to be available. Under present conditions, writes the United States Commercial Attaché at Santiago, it is thought that the time has come to study Chilean woods and their possible utilisation according to modern methods.

An investigation of Chilean timber was made in 1915 by a special agent of the United States Bureau of Foreign and Domestic Commerce, whose report is contained in Special Agents Series No. 117, Lumber Markets of the west and north coast of South America. This pamphlet may be purchased for 25 cents. from the Superintendent of Documents, Government Printing Office, Washington, D.C. Later the Madison (Wis.) Forest Products Laboratory of the United States Department of Agriculture made tests of several varieties of woods and cane for the Chilean Government to ascertain their qualities as pulping material. The following samples were selected for the tests: Olivillo, laurel, coigue, lingue, roble and quilla.

As published unofficially, the following results were given on application of the chemical soda method: The olivillo produced 38 per cent. of pulp, with fibres that averaged 2.15 millimetres (1 millimetre = 0.039 inch) in length. The pulp was dark in colour and 40 per cent. of whitewash was needed. If the caustic solution were strengthened, the pulp could be more easily whitened, but the production would be materially decreased. This wood is especially adapted to the manufacture of wrapping paper in its natural colour, on account of its long fibres. Paper made from olivillo averaged 43 pounds per ream of sheets 24 by 36 inches, and showed a strength of 23 pounds per square inch for paper 0.0044 inch in thickness, using the Mullen test.

Laurel contained fibres which were too short and uneven for good results, and did not compare with the other samples submitted.

The coigue produced 42 per cent. of pulp and only required 19 per cent. of whitewash. The fibres were short, averaging only 0.86 millimetre in length, but the pulp was heavy. Paper for books and other uses could easily be manufactured, provided sulphite of soda were added to the pulp.

Lingue, although appearing to be hard, was easily dissolved. The pulp was similar to that obtained from the coigue, but the fibres, which averaged 1.11 millimetres, were longer, and the pulp obtained had a greater resistance. From

these tests it is believed that both coigue and lingue could be reduced to pulp in the same solution as they require about an equal amount of whitewash.

The roble was easily converted into pulp, which was dark in colour, and, therefore, not recommended for the manufacture of paper.

The quilla is a reed or cane which can be harvested annually, and is found in large quantities. Of all the samples submitted for test, it was found to be the best suited to paper manufacture. Three tests of one, one and a half, and three hours were made, all of which were satisfactory. The pulp produced in the shortest time was the most satisfactory, however, as it was clearer and more easily whitewashed. In this test the pulp was pink in colour, and the fibres averaged 2.22 millimetres in length, with a maximum of 2.66 and a minimum of 1.34 millimetres. A whitewash of 35 per cent. was necessary, chloride of lime being used as a base. The original cost of production would be low, and the pulp is fibrous enough to make the addition of a sulphite pulp unnecessary. The product was found to be particularly suited to the manufacture of newsprint without whitewash, or to the manufacture of light book and similar paper if properly whitewashed. The manufactured paper could also be reduced to pulp and used again after being cleaned.

In addition, there are other woods which are said to be equally or better suited to the making of pulp. Among them are the Araucanian pine (*Araucaria imbricata*), which grows on the Cordillera, and is more readily accessible from the Argentine side, and the canelo, a plentiful and rapidly growing tree, which is a good pulper, but dark in colour. Tests made of the *Araucaria imbricata* are said to have given satisfactory results. The fibres averaged 2.36 millimetres in length and 0.036 millimetre in thickness. A 10 per cent. solution of hydrate of soda was used, the proportions being 26 parts of wood to 100 parts of solution. For the whitewashing process 28½ per cent. of a 33⅓ solution of calcium chloride was used.

The natural centre for operations would be the region south of Puerto Montt, the southern terminus of the Central Railway. Between the island of Chiloe and the mainland is a sound, which has many well-protected small harbours, permitting the entrance of vessels up to 3,000 or 4,000 tons.

GENERAL NOTES.

A Bernini for the Nation.—At the recent Beau Desert sale the Victoria and Albert Museum acquired the beautiful and interesting bust of an Englishman, Mr. Baker, by Bernini. Mr. Baker, of whom nothing else seems to be known, was apparently the messenger charged to convey to Rome in 1636-1637, the triple portrait of Charles I., by Vandyck (now in the National Gallery) from which Bernini made his bust of the King. The "head and Busto of Mr. Baker, in white marble, by Cavalier Bernini," came into the possession of Sir Peter Lely during the sculptor's life-time. At his sale, in 1682, two years after his death, it was bought by the Earl of Kent, and it may be traced through a long line of English collectors, down to its last owner, Lord Anglesey. The bust is now temporarily on view between the pillars of the Central Hall, facing the main entrance of the Museum; it stands on a handsome English pedestal dating from the middle of the 18th century. Sir Reginald Blomfield in a letter to the *Times* (August 11th) states that the Anglesey bust is not the only work in marble by Bernini in England, as has been supposed. "In the east garden of Brocklesbury, in Lincolnshire, there is," he writes, "the fine marble Neptune by Bernini, which I identified in Lord Yarborough's collection some 15 years ago." The authorship of the Cromwell bust in the House of Commons has been attributed to Bernini, but this is disputed. According to Sir William Bull, M.P., the fine bust referred to is "unquestionably by Bernini, "but Mr. Eric Maclagan says there are grounds for believing that it is "a posthumous portrait by Rysbrack."

Brazilian Batiputa Berries.—Batiputa berries are the product of the sandy, rolling, coastal regions of the States of Parahyba do Norte, Rio Grande do Norte, and Pernambuco, where they are prized for their oil, which is said to be equal to the best olive oil and is used for much the same purposes as the latter, having both food and medicinal value. Batiputa berries are of two varieties, wild and cultivated. The wild variety is said to average about 100 to the acre, but the distribution is very irregular, being dependent upon natural seeding. The shrubs are only 7 or 8 feet high, however, so that they would doubtless flourish if planted as close as 10 feet apart, or, say, 400 or more to the acre. Probably most of the land on which the batiputa shrub is found, writes the United States Consul at Pernambuco, is owned by the State governments, but considerable tracts have come into private possession. Public lands, however, may usually be obtained by any one of three ways, namely, homesteading, outright purchase, or a kind of ground rental called aforamento. The batiputa lands are fairly well provided with transportation facilities. Part of the area is near the lines of the Great Western of Brazil Railway Company or the Central Railway of Rio Grande do Norte, and a considerable portion of the remainder is accessible by motor and light vehicles, but pack mules and horses continue to furnish the standard means of transportation in the interior.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2)

PROCEEDINGS OF THE SOCIETY.

EXTRA MEETING.

THURSDAY, JULY 14TH, 1921.

MR. A A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the Chair.

PAINTS, PAINTING AND PAINTERS, WITH REFERENCE TO TECHNICAL PROBLEMS, PUBLIC INTERESTS AND HEALTH.

BY PROFESSOR HENRY E. ARMSTRONG, F.R.S., AND C. A. KLEIN.

In 1913, in a communication to the Society of Chemical Industry on "The Behaviour of Paints under the Conditions of Practice, with special reference to the aspersions cast upon Lead Paints," we discussed at length various important issues connected with the use of paints.

At that time, Departmental Committees of the English Home Office, appointed in 1911, were inquiring into the dangers supposed to be attendant on the use of lead compounds in the painting of buildings and in the painting, enamelling and varnishing of coaches and carriages; the reports of these Committees were published separately in 1915 and 1920.

The question at issue could not be further considered during the war. Meanwhile the situation has been entirely changed by action taken, under the Treaty of Peace, in connection with the League of Nations.

The objective of the League of Nations, in the eyes of the public, is the abolition of war, through the agency of an International Tribunal armed with the necessary authority to adjust differences that may arise between nations: it is not sufficiently realised, we believe, how much wider and more general are the powers with which it would seem to be entrusted and how the operations of the League may influence industry harmfully, unless every precaution be taken to secure proper and judicial treatment of all the problems considered.

On the recommendation of a Special Commission on International Labour Legislation, appointed by the Peace Conference, a special section dealing with Labour was inserted in the Treaty of Peace; the purpose of this section will be clear from the following preamble:—

> Whereas the League of Nations has for its object the establishment of universal peace and such a peace can be established only if it is based upon social justice: And whereas conditions of labour exist involving such injustice, hardship and privations to large numbers of people as to produce unrest so great that the peace and harmony of the world are imperilled; and an improvement of those conditions is urgently required; as, for example, by the regulation of the hours of work, including the establishment of a maximum working day and week, the regulation of the labour supply, the prevention of unemployment, the provision of an adequate living wage, the protection of the worker against sickness, disease and injury arising out of his employment, the protection of children, young persons and women, provisions for old age and injury, protection of the interests of workers when employed in other countries than their own, recognition of the principle of freedom of association, the organisation of vocational and technical education and other measures; Whereas also the failure of any nation to adopt humane conditions of labour is an obstacle in the way of other nations which desire to improve the conditions in their own countries; The High Contracting Parties, moved by sentiments of justice and humanity, as well as by the desire to secure the permanent peace of the world, agree to the following:—

To promote these objects, a permanent organisation has been established, the original Members being the original Members of the League of Nations; hereafter,

membership of the League is to carry with it membership of the organisation.

It is provided that a Conference not only of representatives of the Governments but also of Employers and of Trade Unions from each country concerned shall meet at least once in every year.

Behind the Conference is a permanent International Labour Office, now established in Geneva. This Office is charged with the collection and dissemination of information on all industrial questions of international interest. It is to be anticipated that the Office will frequently bring forward new problems for international adjustment: so that in the system there is a potentiality of a calculated, regular and general improvement of industrial conditions.

At the Conference, each Delegate will be free to express his views and cast his vote in whatever way he thinks best, on every occasion; but all questions are to be decided by a bare majority, except the final approval of Conventions, for which a two-thirds majority will be required. The decisions must be laid, within one year or 18 months at latest, before the proper legislative or other authority in each country for verification. Once a decision has been adopted, every country concerned will be under the obligation to give full effect to it. In the event of default, measures of an economic character may ultimately be taken against the defaulting member.

Over fifty Governments are already participators in this Conference. In the case of many branches of industry, only a small number of nations may be directly concerned with an issue that is raised; therefore, as each nation has the same voting power and a bare majority is to carry a Resolution, the danger that "lobbying" may be practiced is imminent.

The first International Labour Conference was held at Washington in November of 1919. Among the recommendations agreed to was one concerning the employment of Women and Young Persons in certain processes attending the manufacture and use of compounds of lead, which has passed into law in this country in the form of a Bill entitled "The Women and Young Persons Act, 1920." This Act is a striking example of the dangers which may arise from subjects being hurriedly considered, by persons who have no special knowledge of the subject, under the disadvantageous conditions incidental to a polyglot Conference in a foreign country. As originally drafted in this country, the Bill was a mere repetition of the broad recommendations made by the Washington Conference; had the Bill become law in its original form, grave injustice would have been done, through interference with workers engaged in processes from which the risk of danger from lead poisoning had been abolished.

At Washington, the Committee on Unhealthy Processes recommended as subjects to be included in the Agenda for the next Conference:—

(*a*) carbonic oxide poisoning;

(*b*) anthrax infection of wool;

(*c*) the use of nitrate of mercury in "carrotting" by hatters' furriers and the prohibition of the use of white-lead in painting.

It was also recommended, that all countries should make the notification of cases of lead poisoning compulsory. The Committee recommended the formation of a Health Section of the International Labour Office, to keep in touch with the Medical Departments of the Government Offices charged with the application of factory laws. When the danger of purely bureaucratic interference in some matter was pointed out, the full Conference unanimously resolved that "an Advisory Committee, on which the Governments, the employers and the workers shall all be represented, shall be appointed without delay to keep in touch with the work of the Health Section of the International Labour Organisation."

This Advisory Committee, however, is only now in the process of formation; indeed, it was not until April 21st, 1921, that the Governing Body decided to take steps to constitute it.

Of the four subjects thus specifically recommended, the Governing Body of the International Labour Office, at its Session in March, 1920, decided to put on the Agenda of the Conference to be held at Geneva in 1921 only two, namely, the question of anthrax infection of wool and the question of the prohibition of the use of white-lead in painting.

The use of white-lead in paints has probably been the subject of more discussion than any industrial question other than wages or hours of work. The campaign against its use was begun in France about 1800 and has been pursued with considerable vigour ever since. Inquiries have

been held in almost every European country. It is fairly clear that the motive behind the agitation has not been merely solicitude for the workers; trade rivalries have also played a part.

SUGGESTED PROHIBITION OF WHITE LEAD.

As before said, a question to be discussed at the International Labour Conference, to be held in Geneva in October of this year, is "The Prohibition of the use of White-Lead in Painting." No more striking illustration of the way in which prejudice may be created could well be given than is afforded by the Memorandum and Set of Questions dealing with the subject addressed to the various Governments concerned, published in the name of the International Labour Office.

The Memorandum presumably is intended to be an informative presentation of the facts, to guide those called upon to discuss the proposed prohibition of White-Lead: in reality, it is of such a character as to show that the subject has not been dealt with in a scientific manner; the document can only be regarded as an expression of biassed opinion written without sensible appreciation of the many facts to be taken into account.

It is a matter of interest that, when presiding at the reading of the paper on "Immunity and Industrial Disease" by Sir Kenneth Goadby, on May 30th, 1921, the Chairman of the Labour Party (the Right Hon. J. R. Clynes, M.P.) pointedly recognised that our country had not yet overcome one of its greatest enemies, ignorance; he also expressed the hope that, before long, the (Whitley) Industrial Councils would be able to find time to take in hand many important matters of joint interest and mutual benefit both to employers and to employed. That Mr. Clynes should foresee the danger of ill-considered and hasty action is a welcome sign.

Hitherto the attention of Labour has been directed mainly to questions of wages and hours of work: it is evident that, in future, many issues must arise involving scientific problems and that these will not be properly considered unless adequate assistance be secured. Ill-considered legislation may well affect Labour even more seriously than the Employer; in fact it must be to the interest of all concerned that every issue be judicially treated.

We could say prophetically in 1913—"We are advancing into an age when the 'liberty of the subject' may become an unknown quantity; when sentiment and the opinion of an uninstructed majority will more and more prevail over sense and intelligence: unless these latter elements are organised not merely in their own defence but in the interests of the unintelligent majority."

These words may be used with even greater force to express the situation to-day.

The problems presented by industry are both difficult and complex, the more so as human nature must be taken into account: neither is this sufficiently recognised nor is it realised that discrepancies between the conclusions arrived at by individual workers, who almost necessarily have different points of view, are inevitable; too often, however, these arise from incomplete treatment of the subject and it is against incomplete treatment that we must be most on guard.

BRITISH POSITION.

The recommendations of the majority report of the Departmental Committee of our Home Office on buildings were in all essentials identical with those of the unanimous report of the Committee on coach and carriage painting; the former Committee recommended that a law should be introduced, to come into force after a period of three years, prohibiting in this country the importation, sale or use of any paint material containing more than 5 per cent. of its dry weight of a soluble lead compound determined in a prescribed manner. In the case of heraldic painting and fine lining for coach and carriage work, it was suggested that exemption be granted in certain circumstances, so as to permit of the use of lead in colours but not of white-lead for such purposes.

Taking into account the complex nature of the inquiry and the many difficult scientific issues it involved, it is more than unfortunate that the Committees were not expert bodies; not a single member was versed in the use of scientific method; moreover, the witnesses were examined apart, without being informed as to what others had said. It is a striking fact that, the one member with expert knowledge of the painting trade, on the Committee for Buildings, was a dissentient from the report. Few inquiries have been conducted in a more unsatisfactory and less judicial

manner. To base legislation upon such Reports would be to put intelligence aside.*

Among the conclusions we arrived at in 1913, as the result of careful experimental study of the issues then before us, were the following :—

> The toxic effects sometimes experienced from drying paints are to be ascribed to turpentine and due allowance must be made for this in dealing with the hygienic phase of the problem. Our inquiry also shows that, in many cases, effects have been regarded as due to "lead poisoning" which are attributable to other causes, especially to turpentine.
>
> The whole available evidence indicates that the dangers attending the use of lead compounds are only the well-known mechanical dangers.
>
> There is no foundation for the importation of a new element of danger into the consideration of the question of paints. Lead paints are to be objected to only on the ground that they may enter into the system through careless handling or in the form of dust such as is produced by rubbing down old paint.

In our opinion, these conclusions hold in their entirety to-day ; nothing that has happened in the interval appears to us to justify the view that special action is required in protection of the interest of workers in the painting trade other than that of making generally known the simple precautions to be taken to avoid ill effects.

In view of the attitude of the English Departmental Committees and of the Memorandum issued by the International Labour Office, we have extended our inquiries to the operations of painting generally. Our main object in the present paper is to estimate, at their proper worth, the various disabilities of the painter's craft, as summarised in the following schedule :—(See Table I).

VOLATILISATION OF LEAD FROM PAINT.

The need of submitting every statement to rigid criticism may be illustrated by our experience with reference to a communication made to the *Bulletin de L'Académie Royale de Médicine*, of Belgium, in July, 1914, by M. Herman, purporting to prove that lead is volatilised when white-lead paint dries—a bogey which we thought we had disposed of in our 1913 paper.

M. Herman placed discs of filter paper, at unstated distances, above freshly made mixtures of white-lead and linseed-oil, in a closed glass vessel. After 24 hours, the papers were tested ostensibly for lead by means of sulphuretted hydrogen : the appearance of a brown discolouration in the liquid tested was taken as a proof of lead. A control test, using unexposed filter papers, showed no discolouration.

Not being clear what M Herman means by "céruse commerciale délayée dans l'huile de lin, jusqu'a consistance de couleur usuelle," as "céruse" is known in commerce in two forms, as a dry powder and in the form of a stiff paste ground in linseed oil, we used both varieties and made a series of experiments, testing filter papers exposed to white-lead linseed-oil mixtures and also papers not so exposed. Slight brown discolourations were always observed but the effect was no more marked on testing the papers exposed over the white-lead and oil than in the unexposed papers. This aroused our suspicion. The chemicals used had all been supplied as pure : on testing them separately, however, they were found to be discoloured by sulphuretted hydrogen. After they were purified with extreme care, by distillation from silica vessels, they were no longer discoloured : yet the papers behaved as before. The explanation was found, on further study, when the paper was proved to contain sufficient copper to afford the brown discolouration. All filter papers that could be obtained, even those of German origin, contained copper, varying in extent from 0.015 to 0.05 mgms., Cu per disc of 15 cms. diameter. In view of the use of copper and bronze sieves and beaters in paper making and the known affinity of copper for cellulose, the presence of copper in filter paper is not surprising ; that it should be commonly overlooked, however, is remarkable.*

According to M. Herman, "lead" is volatilised only during the first two days after the mixture has been made ; after that time, it could no longer be detected. We have thought it desirable to make experiments not only with freshly made mixtures but also with mixtures of varying age, up to nine months old ; and we have tested mixtures containing turpentine—in

* Since this paper was read, the Home Secretary has appointed a new Committee to examine reports which his Office has received throwing doubt on the conclusion of the two Committees appointed in 1911. We trust that, taking warning, the Home Secretary will appoint persons competent to understand the technical issues.

* We are indebted to Mr. R. W. Sindall for the information that particles of bronze, detached from the beaters, have recently been recognised as the cause of dendritic growths in paper. (See Strachan, *Paper Makers' Monthly Journal*, May, 1919.)

TABLE I.

Purpose.	Operation.	Reputed risk.
Preparation of surface in order to obtain smooth surface— In new and old work.	(*a*) Filling in of cracks and surface irregularities with a stiff paste filling.	Soiling of hands with pigment which is subsequently carried to mouth during smoking or eating.
Ditto.	(*b*) Dry sand papering of intermediate coats.	Creation of dust of dried paint material which is inhaled.
Old work.	(*c*) Chipping off old paint by chisel or similar means. Scraping.	Dust as above.
	(*d*) Dry sand papering of surface to render same smooth.	Dust as above.
	(*e*) Removing paint by paint "remover."	Splashing in the case of caustic removers with injury to skin, in the case of volatile liquids—the vapours of same.
Preparation of paint materials before application.	(*g*) Grinding or mixing of pigment in oil.	Dust of pigment which is inhaled and splashing of paint on clothes and person. In the case of paint splashed on clothes it quickly dries (largely through absorption of the oil by the porous material) and on movement gives rise to dust. Paint splashed on hands, etc., is liable to be carried to the mouth.
	(*h*) Thinning down stiff paste to suitable consistency.	
Painting proper.	(*i*) Actual brush work of the varying kinds and varying circumstances obtaining in practice.	Splashing of paint on clothes and person as above. Production of minute spray which is suspended in the air and, therefore, inhaled by painter. Vapours evolved from the drying paint, *e.g.*, Vapours from the volatile thinner. Vapours from the drying oil. Vapours from the drying paint above being inhaled by painter.

other words, paint as used. *In no case have we detected lead*, although the discolouration due to copper in the paper has always been observed. Incidentally we have ascertained that so small an amount of lead as 0.005 mgrm. in 10 c.c. of fluid can be detected and determined by means of the sulphuretted hydrogen test.

The untrustworthiness of M. Herman's observations is sufficiently proved by his own contradictory statement that, whereas lead was volatilised from a painted surface on to a paper close above it, no volatilised lead could be detected in the air of a room freshly painted with white-lead. The surface exposed in this case was 87 square metres and no lead was detected in 2 cubic metres of air drawn from the enclosure during the 24 hours after painting. This result is to be regarded as a more conclusive proof that volatile compounds of lead are not produced during the drying of white-lead paint than any observations with a few filter papers.

We trust that the suggestion that lead can be *volatilised* from lead paint as used in

practice will not again be heard. Not only did we arrive at this conclusion in 1913 but our observations were confirmed by the Government Chemist, to whom the matter was referred by the Home Office Departmental Committees.

Large scale practice is in agreement with our disproof of the production of volatile compounds of lead in these circumstances. If, as M. Herman asserts, volatile compounds of lead are evolved from white-lead linseed-oil mixtures during the first two days after the mixture is made, then the effect of such compounds should be obvious to workers engaged in the manufacture of white-lead linseed-oil paste or white-lead paint. The methods by which these compounds are manufactured should be favourable to the production of volatile compounds of lead, because the operations are carried out at temperatures higher than that of a laboratory.

As a matter of fact, no single case is on record of ill-effects having been observed amongst such workers which can be attributed to volatile compounds of lead. It is strange that the literature of white-lead paint should contain so many references to a compound of this type; we are convinced that this is because inquirers have not realised that, owing to the extreme delicacy of the tests, it is necessary to exercise the utmost care to prevent contamination by lead.

Volatile Thinning Agents.

Nothing is more surprising than the way in which it has been customary, in the past, to attribute every disturbing symptom displayed by a painter to "lead poisoning." Even in Sir Kenneth Goadby's paper to this Society, read so recently as May 30th, this year, Graphs (Tables V & VI) are given of "*Lead Poisoning*, fatal cases and reported cases for 1900-20, in the Paint, Colour, Coach and Shipbuilding Trades," without one word being said to show that these were *proved cases* of poisoning *by lead*. It is remarkable that Sir Kenneth has not drawn attention to this point, because he is careful, elsewhere in the paper (p.530), to point out that his "own investigations into the action of turpentine on the animal body have clearly shown that usual painters' colic, *i.e.*, the acute attack of abdominal pain so often contracted by breathing the air of newly painted rooms, is turpentine poisoning: many instances of this occur among painters. The affection is popularly attributed to lead poisoning, etc." Further: (Ibid p. 538) "The minute differences between various types of industrial disease, especially lead poisoning and turpentine poisoning, were extraordinary. He knew of a man who was stippling glass with zinc paint and owing to the position of the glass he had to work close up under it in hot weather for three days. During this work, he inhaled the turpentine and had all the symptoms of lead colic and he was reported as a case of lead poisoning."

Ten years ago, when we were called upon to study the matter, we were surprised to find that many of the medical men in this country most concerned with the question of poisoning by paint were by no means alive to the possible effects of turpentine and the other volatile substances used as thinners. Acting on our suggestion, Sir Kenneth Goadby was soon able to obtain proof of the deleterious action of these substances and he gave evidence, at length, on the subject, before the Departmental Committee. In his evidence (Question 15734) he stated that the conclusions to be drawn from his experiments were quite opposed to his own expectation and that until he had read up the literature on turpentine poisoning he was very astonished at the acute symptoms produced. It is important to note that the subject had already been discussed in a "Report of Commission on Occupational Diseases to the Governor of the State of Illinois, U.S.A.," published in January, 1911. This report contains a section entitled "The effects of Turpentine upon the Health of Workmen," which is an account of an actual investigation into the health of painters.

The observations are summarized as follows:—

> "From a study of the above tabulated cases it seems fair to conclude that (1) turpentine vapour is readily absorbed in toxic amounts into the human system; (2) that its vapours are a very frequent cause of conjunctivitis; (3) that it frequently causes severe inflammation of the skin; and (4) that its elimination by way of the kidneys is a common cause of the great frequency of acute and chronic urinary diseases among painters. The principal factor in this deleterious effect of turpentine vapour is the workman's exposure to it in a closely confined room or in a poorly ventilated workshop. In addition, there are various substitutes for turpentine and inferior grades of turpentine.

rapid driers, varnish solvents and varnish removers which are undoubtedly more harmful than pure turpentine. Better ventilation and inspection of ingredients are the obvious corrections.''

Dr. Alice Hamilton (Bulletin of the U.S. Bureau of Labour), in a study of the Hygiene of the Painters' Trade, published in 1912, also recognises the deleterious effects of thinners.

''Paint consists essentially of pigment ground in a liquid vehicle and either the pigment or the vehicle may possess poisonous properties.

''The most important liquids used as ingredients of paint or of paint removers are linseed oil, turpentine, petroleum, benzine or naphtha and benzole. Wood alcohol and fusel-oil products are also sometimes used. These are all volatile poisons, except linseed oil.''

The Inspector of Factories at Hamburg, Herr Schaefer, in 1910, reported a case of fatal poisoning from turpentine vapour and because of several fatalities arising from the use of quick drying paints containing volatile solvents he undertook an elaborate inquiry in this connection. As a result, he issued a leaflet to painters, varnishers, workers in dry docks and others engaged in painting with quick drying paints and oils, describing the dangers attending the use of such paints and indicating the protective measures to be adopted.

In this country, there has been no real appreciation of the dangers attendant on the use of volatile thinners, except in certain industries, such as, the rubber industry, etc., where the ill effects caused by the high concentration of vapour of solvent in the air have been obvious. Early in the war, so regardless were those who had to deal with the use of volatile solvents in the dopes used in aeroplane work, the operatives were allowed to apply the dope in apartments without proper ventilation; consequently they suffered much from sickness and several died. The medical profession seems to have been taken by surprise.

In the discussion of the paper by Sir Kenneth Goadby, one of us pointed out (H.E.A. p. 536) in this connection ''that solvents were used known to chemists as poisonous but not recognised by the medical profession as poisonous; it took a long time for knowledge of such points to permeate the different professions.'' The slow permeation of the scientific knowledge of such matters is a very serious matter and has a direct bearing on the Memorandum of the International Labour Office. The fatality caused some years ago by the use of carbon tetrachloride as a ''dry shampoo'' in a London hairdressing establishment came as a surprise even to those who should have been alive to the dangerous properties of vapours of such compounds.

Poisoning by petrol fumes, a well-known danger, is seldom regarded as being in any way related with or similar to the poisoning risk of the painter.

The Home Office Departmental Committee on the use of Lead in Buildings appears to have been impressed, to some extent, by the evidence submitted to them of the dangers arising from the thinners in paint, as the statement is made in their report that ''it may be found that turpentine and other substances used in paints can produce ill effects sufficient to require action on the part of the Home Office and the Committee therefore considered that, in any Bill to be laid before Parliament to give effect to these Regulations, powers should be provided for the Secretary of State to make Regulations, if he finds it necessary, similar to those which he can establish in Factories and Workshops, under section 79 of the Factory and Workshop Act.'' (Report p. 103).

Notwithstanding all this public knowledge, in the Memorandum issued by the International Labour Office no reference whatever is made to the deleterious effect thinners in paints may exercise: the industrial risk of the painter is set down solely to lead. Those who prepared the Memorandum have displayed striking ignorance of the subject they claim to represent.

In our 1913 paper, we described a method of demonstrating the noxious influence of vapours of volatile paint thinners on the living plant, by exposing leaves of the Japanese or spotted Laurel (*Aucuba japonica*) to their action: the leaves are rapidly discoloured and soon blackened.

Another method is to expose leaves of the common Laurel (*Prunus laurocerasus*) to the vapour, together with a strip of paper which has been dipped in an alkaline solution of picric acid: the yellow paper soon turns orange and then dark brick red, owing to the liberation of Prussic Acid from the leaves.

Recently we have extended the observations reported in 1913 to practically all varieties of thinner in use in paints and varnishes, viz., the following

Amyl Acetate.
Amyl Alcohol.
Benzene and its homologues.
Carbon Disulphide.
Carbon Tetrachloride.
Chlorine derivatives of hydrocarbons, *e.g.*, di-, tri- and tetra-chlorethylene, tetra- and penta-chlorethane.
Ethyl Alcohol.
Ethyl Ether
Wood Spirit.
Impure Methyl Alcohol.
Petroleum and shale naphthas.
Rosin Spirit.
Turpentine.

All these thinning agents are active towards the leaves mentioned, the rate at which activity is manifest depending mainly on their volatility; but the specific character also has its effect. Thus benzene is more rapidly active than a light petroleum of about the same boiling point, an observation strictly in accordance with conclusions based on observations in actual practice. Thus Dr. Alice Hamilton (loc. cit. page 12) states:

> "Because of its increasing use in many manufacturing processes, there has been a good deal written of late, especially in Germany, on the poisonous effects of the vapours of benzole or benzene and the Germans distinguish clearly between poisoning from this substance and poisoning from benzine, which is less volatile and less dangerous."

The chlorine substitution products and other rapidly volatile solvents in use in the now popular quick drying paints are specially active.

In point of fact, all solvents of oil which can be used in paints and varnishes as thinners are lethal substances. It is only seldom that painters compelled to work in confined spaces are overcome by their vapours: such cases must be regarded as abnormal, because they are, in fact, acute cases of poisoning, due to the high concentration of the vapours in the air breathed. In the ordinary practice of house painting, the worker is exposed almost daily, during long periods, to air containing vapours at a low concentration; under such conditions, owing to the slow nature of the attack, the effects are frequently overlooked, though deep seated changes may be in progress, the extent of which, even to-day, is not fully appreciated.

Rate of Volatilisation of Turpentine and its Substitutes.

1913 paper, we called attention to the rapid rate of volatilisation of turpentine and its substitutes, when exposed to air; and the significance of volatility, as affecting the amount of vapour in the air breathed by the painter, was also pointed out.

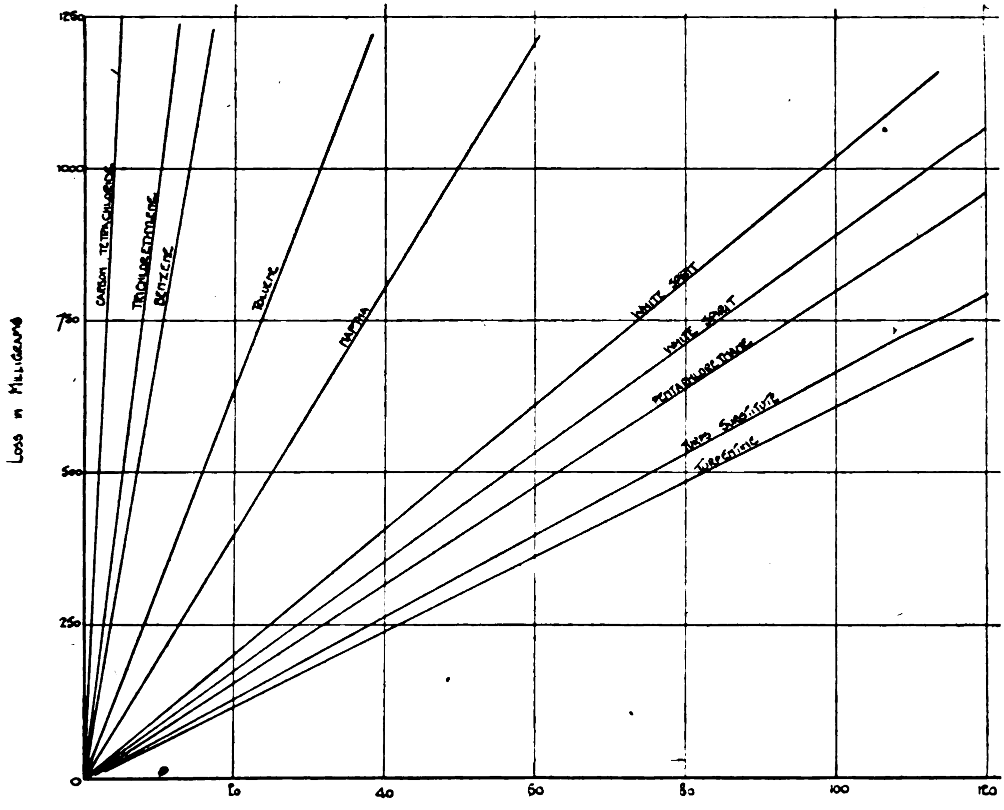
We have made a new series of experiments on the subject and have determined the comparative rates of volatility of a number of thinners and also the rate of evaporation of thinners from paints in which they were present to the extent of 5 and 15%. The results are shown in graphs 1, 2 and 3.

Graphs 2 and 3 show the results of frequent determinations of the loss in weight during the first hour of exposure; these prove the rate of evaporation to be even more rapid than was indicated in our earlier paper.

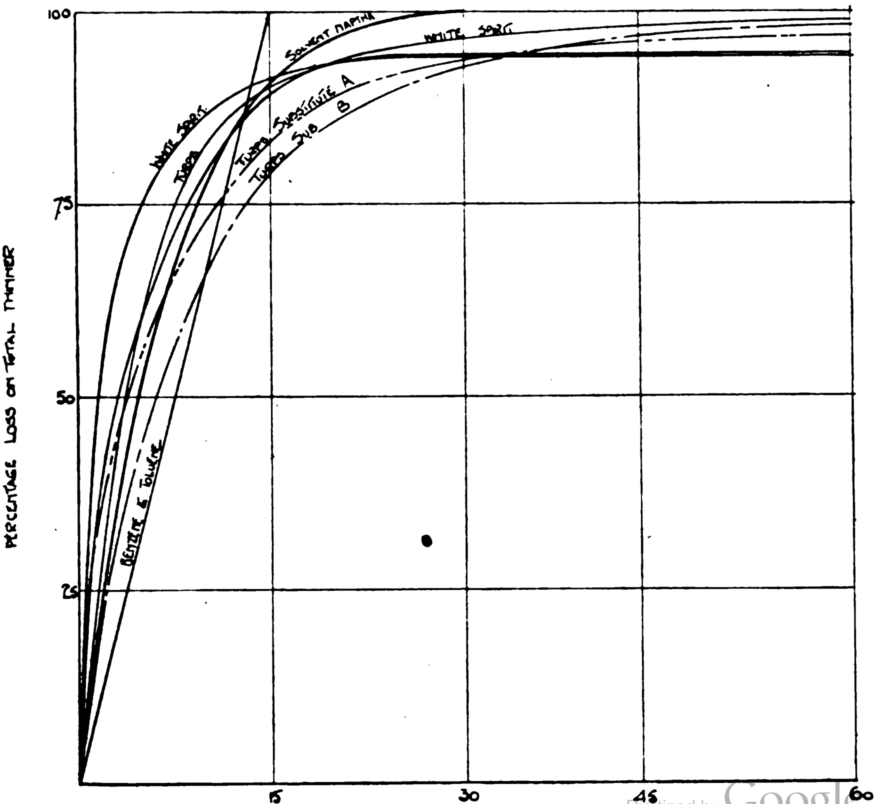
Out of 15 paint mixtures specially prepared, only 2 failed to lose over 75% of the volatile thinner within 15 minutes. This rapid volatilisation of the thinner is a fact of great importance. In order to give full significance to the risk the painter runs from this source, we have directly estimated the quantity of turpentine present in the air at the breathing point of a man engaged in applying white lead paint containing 5% of turpentine. Two such determinations have been made.

In the first case, that of a single painter applying paint to a wall, the air in the vicinity of the man's mouth contained 3.2 mgms. turpentine per litre; whilst in the second case, in which two painters were working close together (one painting the wall and the other painting woodwork, using the same type of paint), the air inhaled contained 4.9 mgms. turpentine per litre. The importance of these figures is apparent in view of the work of Lehmann, Goadby and Alpaugh.

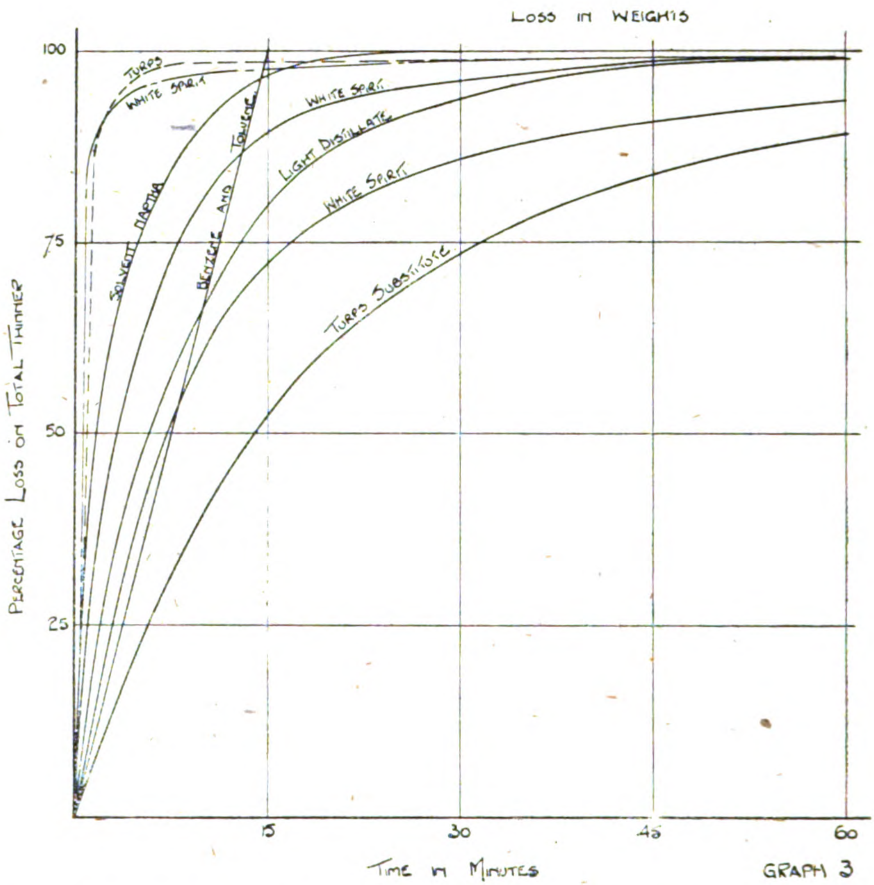
Lehmann (Archiv für Hygiene 1899. S. 321) has shown that when animals are subjected to air charged with turpentine vapour to the extent of 3 or 4 milligrammes of vapour per litre of air, severe symptoms are induced. The turpentine acts as a local irritant and when absorbed into the lungs has an exciting effect on the central nervous system. Inhalation of large quantities of turpentine vapour causes rapid breathing, palpitation, giddiness, stupor, convulsions and other nervous disturbances, pains in the chest, bronchitis and inflammation of the kidneys. The last-named symptoms also arise from the chronic action of turpentine vapour, which is of chief importance in this connection.



GRAPH 1



GRAPH 2



GRAPH 3

Goadby (Home Office Departmental Committee, Question 15,740) states that a concentration of turpentine of 8 mgms. per litre produced symptoms of poisoning in himself but does not name the period of exposure.

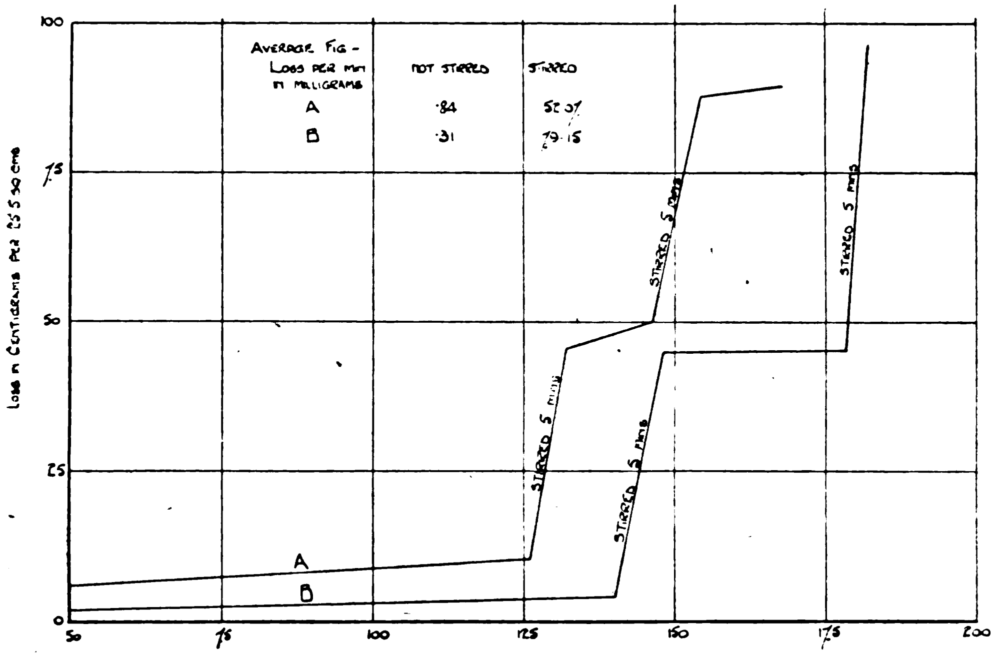
Alpaugh, Ohio, Pub. Health, J. 6. 512-4 (1915) has determined the toxicity of various volatile media and states that benzene, naphtha, gasoline, or petroleum-ether to the extent of 0.02 g. per litre of air will cause local symptoms, whilst 0.05 g. per litre of air is poisonous. Benzene 0.015 g. per litre of air is poisonous, whilst 0.042 g. per litre will kill dogs in 20 min. Turpentine 0.003 g. per litre of air cause local symptoms, whilst 0.006 g. per litre poisons a healthy man in from 1 to 4 hours.

These figures show that in using paint containing 5% turpentine, a painter may be exposed to a concentration of turpentine vapour known to be toxic, so that the effect of the repeated inhalation of vapour involved in the painter's occupation cannot in any way be disregarded. Flat paints containing larger quantities of thinners are obviously more dangerous. The whole subject is of first importance and should receive close attention. The work of Rambousek, von Jaksch, Delpech and Laudenheimer and others, even if known, does not appear to be appreciated outside a limited circle.

Volatile Constituents of Paint Removers.

We have recently examined two paint removers which contained volatile liquids. In both cases, the vapours evolved were found to be particularly active, as was shown by the aucuba leaf. Graph IV., indicating the rate of evaporation of the volatile constituent, is of particular interest as illustrating the precise behaviour of these materials in practice. On exposure to air, volatilisation takes place during a short time and then ceases, the graph becoming practically flat, showing an arrest in volatilisation. This is due to the fact that the paint remover forms at the surface

of application a saturated solution of a material which is deposited as a film immediately volatilisation takes place; the film protects the paint remover from further rapid evaporation, so that it becomes retained at the surface which is being treated. By this means, the loss of volatile thinner is much decreased and only when the surface is disturbed does the rate of volatilisation become at all rapid. Both effects are shown in the graph, which indicates the difference in behaviour between paint removers and the ordinary volatile thinners used in paint.



GRAPH 4

Effects on Skin.—One other effect of thinners to be referred to is their direct action on the skin, *e.g.*, Russian turpentine, which is often used in the cheaper paints, is a peculiarly powerful skin irritant to some persons: the effect is far more marked than with either French or American turpentine.

[A slide shown was a photograph of the hands of a worker engaged in painting the inside of casks with paint containing Russian turpentine. The back of the hand and wrist became splashed with paint and severe dermatitis followed.]

It is probable that some of the chlorinated compounds now coming into use will need to be applied with discretion to avoid such effects. This caution may be given specially with reference to paint removers, which are solvents of peculiar efficiency.

Possible Risks Through Mechanical Operations.

Burning Off Paint. The important question has often been raised whether, in burning off old paint, lead may be volatilised or leady dust be created. With one single exception, the literature of the subject appears to be confined to opinions and as they are only opinions, we do not propose to concern ourselves with the statements that have been made. The only published work on this subject which we can trace is that of Mr. G. E. Duckering, referred to in appendix 13, page 16, of the Home Office Departmental Report. Mr. Duckering examined air collected near to the mouth of workmen engaged in burning off old paint from locomotive and coach bodies and describes four experiments made under different conditions. Taking the worst case quoted, viz., determination No. 21, which involved burning off white paint from a L. & N.W. coach, the amount of dust present in the air was 52 mgms. in 10 cubic metres; it contained 6.5% lead, equivalent to 3.4 mgms. of lead per 10 cubic metres. The white paint of the L. & N.W. Railway coaches is white-lead paint and therefore

the conditions must be regarded as involving maximum exposure.

According to Dr. Legge (H.M. Inspector of Factories Annual Report Chief Inspector of Factories, 1912, p. 199), about 4½ cubic metres of air pass in and out of the lungs in the course of a 10 hour working day. On the present 8 hour day, this figure can be taken as 3.75 cubic metres—which according to the above maximum figures of Mr. Duckering would mean the inhalation of 1.27 mgr. per working day.

Basing their opinion on the view of Dr. Legge and Sir Kenneth Goadby, expressed in "Lead Poisoning and Lead Absorption" Arnold. London. 1912, p. 207:—

> "Somewhere about 2 milligrammes we regard as the lowest daily dose which, inhaled as fume or dust in the air, may, in the course of years, set up chronic plumbism,"

the Majority Report of the Home Office Departmental Committee on Painting concluded that (page 3)

> "it therefore follows that some figure between 2 and 4 milligrammes of lead per 10 cu.m. represents the maximum extent to which the atmosphere may be vitiated without becoming a source of lead poisoning."

The experiments of Mr. Duckering show the process of burning off to be one which falls within these limits and therefore is one which can be disregarded as a source of danger, even if workers were continuously engaged in this work. In point of fact, the operation of burning off is never the continuous task of any worker. It is a process only used in special circumstances and is now being steadily displaced by direct rubbing down with pumice stone and water, if not by removal of the paint either by alkaline liquids or by paint-removers containing volatile constituents, as previously mentioned.

We have made experiments in this connection — the method adopted being to remove the fumes produced in the burning off process by means of a funnel, provided with an exhaust draught, held against the painted surface immediately above the flame of the blow-lamp and so arranged as to move in unison with the flame and scraper. The exhaust air was filtered and after the experiment the filter was examined for lead. The quantity of lead obtained was equal to 0.001 mgrms. Pb per square yard of 4-coat white-lead paint burnt off: this is an extremely small amount The actual operation of burning can therefore be disregarded as a source of danger: whether the lead be volatilised or carried over in fine spray from the charred paint material is immaterial, the quantity of lead determined at the surface being negligible.

One possible source of danger in connection with the operation of burning off has come to light. We have observed that it is the general practice of the painter to knock the paint scrapings on to the floor immediately the scraper is full; as the scrapings are often glowing in part and are brittle; it is conceivable that dust may then arise; further, in our experience, the clearing up of such scrapings is an operation which does give rise to a certain amount of dust. This danger may be easily overcome if the painter empty his scraper into a vessel containing water close to his work.

Dangers Due to the Mechanical Operations of Painting.

Paint splashed on to overalls is regarded as a serious source of danger, as it is found that paint splashes readily dry and that dust of the pigment is created by the handling of soiled overalls. So important is the matter regarded in official circles, in this country, that the danger is specially named in the Women and Young Persons Bill (1920). On looking into this matter, we were much surprised that we were unable to find any record of an experimental study of the extent of the supposed danger. The only direct observations with which we are familiar are those of M. Herman, described in the communication to which we have already referred.

On carefully considering M. Herman's work, we realised the necessity of a fuller inquiry and this we have undertaken.

In the Herman experiments, a room 4.7 by 4 by 5 metres high was painted with a mixture of white lead, linseed oil and drier, to a man's height. The painter was provided with a cap and a collar (covering shoulders, chest and back) cut from absorbent (filter) paper. These coverings were worn during painting, so that splashes falling on the painter during painting might be detected. To detect the splashes, the papers were exposed to the vapour of osmic acid, which causes the blackening of oil, thus making any spots on the paper covering visible.

(In our experience, the oil spreads on the paper and the stain as developed by the

osmic acid is from twice to three times the width of the original splash). After the painting was done, the paper used as a collar was cut into four pieces, representing the right and left front and right and left back. On the right front, 49 splashes were visible to the naked eye after treatment with osmic acid, although only 3 were previously visible. Low magnification (6 diameters) showed other spots of smaller dimensions. The other three pieces of paper gave similar results but the spots were less numerous; no spot was visible prior to exposure to the osmic acid vapour.

M. Herman does not appear to regard these splashes as serious sources of danger and passes at once to an investigation of minute splashes (size unnamed) the existence of which he claims to have demonstrated; this question is discussed by us later in the paper.

For the purpose of our inquiry, we selected a room in a private house which had been painted 10 years previously and the services of a journeyman painter were retained for the practical work. Happily, this painter, in addition to being a capable craftsman, was willing to give every assistance and readily submitted to the somewhat unusual demands made upon him in respect to clothing, etc.

In order that the results should have practical value, we decided to leave the actual painting operation entirely in the hands of the painter, insisting only that the methods used should be those of practice—the painter being instructed to follow his ordinary procedure, the chemist in charge of the inquiry not being permitted to interfere with his work. The actual work carried out was as follows:

1. The overhead HORIZONTAL surface painted was a plain plaster ceiling with moulded edge and centre floral moulding—the total area being 144 sq. ft. After being sized, the surface was painted with one coat each of flat, medium and glossy white-lead paint in three successive days.

The VERTICAL surface consisted of the dado (plaster), large panelled folding doors, one panelled ordinary door, skirting boards, window frames and sashes and mantelpiece, having altogether an area of 209 sq. ft. The vertical surfaces were painted with three coats, exactly as in the case of the horizontal overhead surfaces, after being dry-rubbed down.

The paint used was genuine white-lead mixed with linseed oil, turpentine and the necessary drier. In the case of the glossy paint, good quality indoor varnish was added.

Overhead (Horizontal) and vertical surfaces were painted on separate days, so as to avoid any complications. It is obviously impossible, in a communication of this kind, to detail every result and observation as these were both varied and numerous; we therefore only give illustrative examples together with a general summary of the experiments, indicating the conclusions to be drawn therefrom.

The investigation has been prolonged and very tedious and numerous additional inquiries have been necessary in order to reconcile some of the unexpected variations observed; but we can say that the variations and apparent anomalies were all explained by means of experiments specially designed to elucidate points in question.

During each experiment, the painter was clothed as follows: On his head was a square cap made in one piece; the shoulders, chest and back were covered by two pieces, in such a way that when in position a sleeveless coat was formed; the arms were covered with sheets of paper arranged in the form of sleeves, so as to afford freedom of movement; lastly, an apron was arranged so as to protect the stomach and the legs half way to the knee, the material used, in all cases being best quality sheet filter paper.

A complete set of clothing was used in each experiment and the splashes were developed by exposure to the vapour of osmic acid, in the manner indicated by M. Herman.

OVERHEAD HORIZONTAL SURFACE (Ceiling Experiments).

Each coat of the paint was first applied with a 1lb. ordinary painting brush and then stippled. Four pieces of filter paper, each 18 inches square, were disposed on the floor in such positions as to collect the splash falling from the different type of surface painted, namely,

(1) A right angle junction of cornice moulding.
(2) Plain ceiling.
(3) Straight run of cornice moulding.
(4) Irregular floral moulding in central room.

The papers were left down during half-an-hour after the painting was finished; they were then removed and exposed to the vapour of osmic acid for 24 hours. The splashes which appeared were counted and in order to facilitate the count of the smaller splashes the sheets were ruled into 36 squares, only six of which were counted. The total count was sub-divided into groups according to size, so that it is possible to compare not only numbers but also the sizes of splashes produced by variation in type of surface and of paint.

The smaller splashes were evenly distributed on all sheets but this was not so in the case of the large splashes; the latter appear to be produced immediately the ordinary paint brush is applied to the surface and not by the stippling tool. The actual figures obtained were as shown in Table II.

It must be borne in mind that the quantity of paint represented by such figures is extremely small.

We regret that it is not possible to reproduce effectively any of the spotted "test papers." Their appearance is most striking, particularly on account of the clear way in which the individual black dots stand out, like stars in a clear sky; they are nowhere huddled together in patches.

INFLUENCE OF SURFACE ON SPLASH PRODUCTION.

If the splashes produced on the corresponding sheets for the various kinds of paint be totalled, the following ratios are obtained:

	Sheet 1.	Sheet 2.	Sheet 3.	Sheet 4.
Splashes 1 mm. & over	3	4	4	4
„ less than 1 mm.	1	$1\frac{1}{2}$	2	$3\frac{1}{2}$

It was observed that in painting the right angled bend of the cornice moulding, over sheet 1, the painter worked more carefully and was forced to make short strokes with the brush, as the wall at that point was only 15ins. long; hence it was that fewer splashes were found on this sheet than on those under the open ceiling or plain cornice; in these cases, the painter made long and fairly vigorous strokes with the brush, tending to the formation of splash.

CONCLUSIONS. The total number of the larger splashes is comparatively small and is not seriously affected by the type of surface. Irregular surfaces notably increase the number of small splashes.

TABLE II.

Splashes per square yard.

		10 mm. & over.	5-10 mm.	3-5 mm.	1-3 mm.	Less than 1 mm.
Exp. 1.—"Flat" paint ...	Sheet 1	4	12	52	552	11700
	„ 2	4	12	24	624	24500
	„ 3	4	28	60	504	35400
	„ 4	12	8	8	312	38100
Exp. 2.—"Semi-gloss" paint	Sheet 1	0	0	4	240	14500
	„ 2	4	8	8	456	12600
	„ 3	16	28	40	576	23700
	„ 4	4	8	20	648	41700
Exp. 3.—"Glossy" paint ...	Sheet 1	0	4	4	52	5100
	„ 2	4	0	12	44	4000
	„ 3	0	0	0	28	4600
	„ 4	0	4	12	184	22700

Influence of Different Paints on Splashing.

Examination showed that in all cases the glossy paint produced less splash of all sizes than "flat" or "semiglossy" paints, thus:

Ratio of number of splashes for different coats.	FlatCoat 1.	Semi-glossy coat 2.	Glossy coat 3.
Splashes 1 mm. and over ...	8	6	1
Splashes less than 1 mm. ...	3	$2\frac{1}{2}$	1

There is little difference in the splashing between the "flat" and "semi-gloss" paints.

Conclusions. These trials show that for similar surfaces the splash produced is dependent on the fluidity of the paint—fluid paints give rise to more splash.

Numbers of Various Sized Splashes.

Table II. shows that the greater number of the splashes produced are all less than 1 mm. in diameter and that the number of those greater than 1 mm. diminishes rapidly as the diameter increases. To obtain a general comparative ratio of the number of different sized splashes, the sum total of the 12 sheets was taken and the average value per sq. yard calculated.

The following values were obtained:

Splashes per sq. yd. (average of 3 expts. all sheets).

Greater than 10 mm.	5-10 mm.	3-5 mm.	1-3 mm.	Less than 1 mm.
4	10	22	351	20,000

Thus splashes less than 1 mm. diameter number about 50 times the total of all other sizes.

Examination of Painter's Clothing. (Overhead horizontal trials).

It was obviously impossible from this experiment to draw any conclusions as to the relative effect of surface in the production of splashes on the painter's clothing, because the same clothes were worn while painting the whole of the ceiling; therefore, the clothes represent a combined effect on types of surfaces. The distribution of the spots and the total quantity in reference to the type of paint is important, although numerical comparisons appear to have little value and have not been attempted.

Notes. It will be seen that the glossy, *i.e.*, thicker paint, causes less splashing on the man's body than the more fluid paints, a result in general agreement with that demonstrated by the floor papers. The distribution is of interest, as showing that, in the operation of overhead stippling, a painter must be regarded as being in a shower of falling drops and any surface presented to this shower as liable to be splashed; thus the left arm, extended as it is at times to preserve balance and to carry the paint kettle, is often as badly splashed on the forearm as the right or painting arm. The clean condition of the cap is to be explained by the fact that only the front of the cap is exposed to the falling splashes, as the head is bent back during the operation and is largely out of the splash zone. In view of the position of the face, a special trial was made in which the face of the painter was covered with a filter paper mask during 2 hours stippling of a plain ceiling with glossy white-lead paint. On

Paint.	Cap.	Shoulders.	Arms.	Apron.
1. Flat.	Few spots on front of cap only.	Spotted right shoulder; both sides chest.	Right arm badly spotted. Large number of fine spots front of left arm: forearm badly spotted.	Much spotted. many fine spots.
2. Medium.	Ditto.	Spotted right shoulder, right back, both chests; less on chest than on 1.	Right arm badly spotted; left arm but not so bad as in 1.	Equally spotted.
3. Glossy.	None.	No spots on back and shoulders. Very few spots on left and less on right chest.	Right arm slightly spotted $\frac{1}{4}$ to bottom left, spots just over wrist and odd spots elsewhere; very few.	Much less than 2.

treatment with osmic acid vapour, the mask showed that a considerable amount of splash falls on to the face—the low concentration on the forehead is in agreement with the observations made on the caps, the higher concentration in the vicinity of the mouth being due to its closer proximity to the stippling tool and its position relatively to the falling particles. Although the splashes produced represent an extremely small quantity of paint, we feel that this is an operation in which a suitable light respirator or filter might, with advantage, be worn over the mouth.

The question of stippling is dealt with in the report of the Home Office Committee, page 84, in the following manner:

> "Fine spray is produced by the process known as 'stippling,' that is to say, beating a fresh coat of paint with a hard flat brush in order to spread it out evenly over the required surface. The actual risk entailed by a single operation of this kind is very small but such as it is, it constitutes an additional danger.
>
> "The process of 'stippling' is sometimes carried out by the workman who actually lays on the coat of paint but more often by another workman; and in the latter case both are exposed to the risk of inhaling the spray from the stippling tool. Some spray and splashing of paint is inevitable in connection with ceiling and other interior work but for these lead paints have already been largely displaced by leadless paints or distempers."

In our opinion the men engaged in this operation should either wear a light respirator or fix a piece of rag over the mouth; the arms should be protected by a simple covering such as can be readily improvised from newspaper fixed with rubber bands or string; whilst the shoulders can easily be protected by tearing a circle from the centre of a folded newspaper and inserting the head through the hole, forming a cape which will adequately protect the usual overall worn underneath.

To ascertain the quantity of lead falling on the painter during stippling, an experiment was made in which discs of filter paper were pinned, in various positions, to a man engaged during 1½ hours in stippling an overhead surface. The following are the results:—

Total Lead per 14.7 sq. inches (11 cm. filter paper).

	Lead Milligrammes.
Left Fore Arm	4.0
Left Arm, Top ..	3.4
Right Fore Arm ..	26.0
Right Arm, Top ..	15.0
Left Shoulder	3.6
Right Shoulder ..	4.0

At the same time, the quantity of the lead paint was determined which fell upon an area of 2 square inches, in the region of the mouth, nostrils and chin of the painter engaged in stippling a plain ceiling during 1½ hours. The amount in terms of lead was 0.09 milligrams. It is, therefore, apparent that the mouth of the painter is in such a position relatively to the falling spray as to be practically out of the danger zone. This is clearly a result of primary importance.

Rate of Fall of Splashes Produced in Stippling Overhead Surfaces.

Experiments designed to determine the rate of fall were made by stippling a horizontal overhead surface over a rotating drum 3ft. in diameter covered with filter paper. During the time that the stippling brush was applied, the drum was revolved at a known rate: it was found that the larger particles fall more rapidly than do the smaller particles, the approximate rates of fall being as below:

Size of measured splash in microns.	Time. Secs.	cm/sec.
510	0.4	160
340	0.8	80
170	1.5	40
85	1 9	30

The observation is of interest in connection with observations subsequently made

with reference to minute splashes, which it has been suggested exist and remain in suspension in the air. The important fact established is that the splashes that are produced readily fall to the ground.

VERTICAL SURFACE.

In studying vertical surfaces, the painter was clothed for each coat of paint in the manner previously described. Five strips of filter paper 1ft. wide were placed on the floor and extending outwards from the wall at right angles to the different types of surfaces painted.

The plaster-dado and all the wood work were painted with an ordinary brush. The three coats of paint applied were flat, semi-glossy and glossy as before. Papers were placed in five positions as under:

- *a* and *b* were duplicates, each being placed in front of 8ft. panelled folding doors.
- *c* in front of 10-inch skirting broad.
- *d* in front of window frame vertically below the right hand of moulding.
- *e* in front of one side of mantel piece, which was panelled with floral panel raised in relief.

The papers were in position during the painting and 30 minutes after.

Examination of the papers showed that 95-98% of the splashes produced in the ordinary painting of vertical surfaces fall within 6 inches of the painted surface—those falling beyond this distance being irregularly distributed large splashes.

EFFECT OF SURFACE: It was at once obvious that there is less splash in the painting of plain surfaces than of irregular surfaces such as panels or beading. Large splashes were almost absent in the painting of plain surfaces, the reduction in the number of small splashes being very marked. Horizontal projections, such as window ledges and beadings, cause the bulk of the splashing.

EFFECT OF DIFFERENT PAINTS ON SPLASH FORMATION: The results entirely confirm those obtained in the ceiling experiment, viz., that the thicker the paint the less the splash produced. The difference in this case, however, between semi-glossy, and glossy, was not so marked.

EXAMINATION OF PAINTER'S CLOTHING: (Vertical Surface Trials).

There was at once a striking difference in the condition of the clothing between the two sets of experiments, the splashing produced in the painting of vertical surfaces being almost negligible when compared with the stippling of horizontal overhead surfaces. The condition of the clothing was as described below:

Paint.	Cap.	Shoulders.	Arms.	Arms.
4. Flat.	None.	Shoulders and back unspotted. Odd spots, 6 in all on right chest; none on left.	Odd spots right arm—most by wrist, few in number. Left unspotted.	Very few fine spots and equal number of small spots.
5. Medium.	None.	Nothing on back or shoulders; say one dozen on each right and left chest.	Ditto (as 4).	No small spots; few large ones.
6. Glossy.	Very few on front of cap.	Left back and shoulders unspotted. Right back unspotted. Right shoulder distinctly spotted, but not so bad as 1 and 2, but worse than 3, 4 and 5. Right and left chest equally spotted—double No. 5.	Ditto.	Very few spots. All smaller than 5.

The Ratio of Different Sized Splashes Produced on clothing in painting vertical and overhead horizontal surfaces is as below :

	Greater than 3 mm.		1-3 mm.		Less than 1 mm.
Overhead horizontal painting (stippled)	1	:	19	:	1120
Vertical Painting ...	1	:	9	:	278

The figures for the overhead horizontal surface show that the splashes less than 1 mm. are about 50 times as numerous as the sum of the other sizes, which is in agreement with the figures obtained from papers placed on the floor in experiments 1-3.

In the case of the vertical surfaces, where no stippling has taken place, the number of smallest splashes (less than 1 mm.) is only about 28 times the sum of the other sizes and it is clear that stippling is a process in which the production of small splashes is much increased.

It is to be noted that more splashes appeared on the clothing when using the glossy paint as final coat. This is not to be attributed to the paint but to the fact that, in the final coat, the painter took considerable pains to leave his surface in a proper smooth condition ; this is done by lightly smoothing the paint by a rapid sweeping movement of the brush, which is responsible for the throwing of the splashes.

Splashing on the Face — Plain Painting and Stippling of Vertical Surface : No splash was observed on the face of the painter who made these experiments. In a special experiment, in stippling a vertical surface, the face of the painter was protected by a paper mask similar to that used for the painting of the ceiling; after 2 hours' use of the mask no splashes could be detected by the treatment with osmic acid vapour.

General Notes on Paint Splashes Produced in Painting Vertical Surfaces.

The practical importance of the observation that over 95% of the splashes produced in painting and stippling (an unrecorded experiment showed that this was true also in the latter case) of vertical surfaces fall within 6 inches of the surface will be obvious. A painter stands at an average distance of 15 inches from the surface he is painting and is, therefore, outside the splash zone. In a series of special experiments painters were caused to carry semi-circular pieces of paper of 6 inch radius projecting outwards from empty respirator frames fixed over the mouth ; these were worn during two hours,

while a vertical surface was being painted (ordinary brush work and stippling). On treatment with osmic acid vapour the papers showed about 40 splashes in each case. The smallest splashes were 1.5 mm. in diameter, equal to an original drop of approximately 0.5 mm. diameter. No smaller splashes could be detected.

As it was then desirable to ascertain whether, while breathing, a painter exerts a sufficient suction to draw particles into his mouth or nose, two tests were applied. In the one a painter wore a respirator during 2 hours: the filtering material did not contain lead after this period. In the second, air drawn away from the cheek of a painter at mouth level was passed through a filter during two hours; again no lead was detected in the filter. Thus it was established that neither in vertical painting nor stippling, does the painter inhale paint splash or spray.

Path of Falling Paint Splash from Vertical Painted Surface.

As there is much more painting of vertical surfaces than of horizontal overhead surfaces, it was considered advisable also to ascertain approximately the path described by the falling paint splash. A splash must be projected from the vertical surface and its falling path is obviously determined by the angle at which it leaves the surface. The following experiments were made to obtain information on this point.

(1.) The horizontal distances of splashes from a vertical surface were determined after falling from various heights.

It was found that there was no sensible difference in distance or distribution of splashes at any heights between 1 ft. and 12 ft.; it is therefore clear that, within less than twelve inches below the point of projection, the splash falls vertically and does not, as has been suggested, travel any considerable distance away from the vertical surface.

Horizontal Movement.

(2.) It was known that in the stippling of a vertical surface, particles are projected from the vertical surface and travel into the room to a distance extending not more than 6 inches outwards, although the course travelled, being at an angle less than a right angle, is obviously much greater.

Experiments showed that such splashes may travel a distance of 15 inches from the edge of the stippling brush; in no case was it found that the particles went further into the room than the above mentioned 6 inches. The experiment confirmed the earlier observation, namely, that at a distance of 12 inches from the point of application the particles had all assumed a vertical path of descent.

Comparison of Number of Splashes Produced in Overhead Horizontal Stippling and Vertical Ordinary Brush Work.

It has been pointed out that there is an enormous and obvious difference in the amount of splash produced by these processes; the following figures confirm this in a striking fashion;

Average figure for 3 coats. Ratio of splashes produced.	Overhead horizontal stippling.		Painting vertical.
Greater than 3	10	:	1
1·3	20	:	1
Less than 1	40	:	1

Size of Paint Splashes.

Statements have been made to the effect that painting gives rise to minute spray which long remains suspended in the air. We have studied this matter with great care. The splashes were collected by arranging clean glass plates immediately below the surface to be painted, placing them in position before the painting was commenced and leaving them either 30 mins. or 24 hours after the painting was completed, the room meanwhile being undisturbed: in certain cases, the plates were put into position half an hour after the painting was finished, in order to allow all large sized splashes to settle.

The plates were then examined with the microscope, the picture being thrown on to a screen at a magnification of 2,000 diameters and the splashes measured. Hundreds of fields have been examined and in no case have paint splashes less than 30 microns diameter been detected. As some flattening of the paint splash takes place on the glass plate, the apparent measurement is greater than the original diameter of the splash.

It is important that, in making the experiment, dust be avoided, otherwise specks of dust, irregular in shape, sometimes crystalline and transparent, are found on the slide and these have been detected as small

in size as 3 microns. By excluding dust and using the osmic acid staining and sulphuretted hydrogen tests, perfectly definite images of paint splashes can be obtained having a minimum diameter of 30 microns.

In addition to glass plates, we have exposed filter papers: *apart from obvious spotting, the papers showed no general discolouration or lowering of tone.* We have, therefore, no hesitation in asserting that the spray takes the form of relatively large spots; moreover, the production of very minute drops of an oil is not to be expected.

MINUTE (MICROSCOPIC) SPLASHES.

M. Herman (loc. cit) found and we agree, that it is impossible to employ high magnification on filter paper, owing to interference by the fibres of the paper. Questioning whether spray of a much finer order than that detected by him might not be present in the atmosphere of a freshly painted room, M. Herman had his experimental chamber repainted by four men in the course of an hour. Half an hour later, pieces of paper 27 by 23 centimeters in area, suspended at various heights, were distributed about the room. These were exposed during 24 hours in the sealed chamber and then tested chemically for lead. The two nearest the top were free from lead; in the next four, there was a feeble indication; in the remaining fourteen, it is stated, the indication was clearly positive.

These observations were considered by M. Herman to afford proof of the existence of "gouttelettes plombiferous microscopique"—which could remain in suspension in the air a sufficient length of time for at least part to be inhaled by the worker.

We are entirely unable to understand these results, as on making similar trials, we have obtained no such evidence. We have had a ceiling (area 144 sq. ft.) painted on three separate occasions and half-an-hour afterwards have placed sheets of paper below it, in duplicate, on a series of steps, at intervals of ten inches, down to the floor. After 24 hours, the papers were submitted to the vapour of osmic acid and also to the ordinary lead test which involves extraction by acid and also incineration. *In no case was either oil or lead detected.*

In these trials, the paper was exposed immediately below the painted surface, not at right angles to it, so that if there had been any subsidence of fine spray, this must have been retained. M. Herman appears to have painted only the walls of his chamber. We therefore have made three trials with painted vertical surfaces, using test papers placed immediately against and at right angles to the painted surface: *again with negative results.*

In these experiments we have used three types of paint, viz., flat, medium gloss and glossy. These paints are paints such as are used in actual practice, in that they contain turpentine, whereas in his experiments M. Herman used a mixture of white-lead, linseed oil and drier without volatile thinner.

The method of exposing paper half-an-hour after the painting was completed is open to serious objection, in that these are not the conditions to which the painter is normally exposed and the more drastic test is the examination of the air actually breathed by a painter during the painting operation. As stated, we have made trials in which air has been aspirated through a horizontal filter arranged at the side of the face and level with the mouth of the painter, during an actual painting operation on a vertical surface: we have always failed to detect either lead or oil.

In view of this observation, confirmed as it is by the previously described glass plate tests, we are justified in concluding that no minute spray of the kind indicated by M. Herman exists either in the air breathed by the painter or even near to the painted surface. We have shown that, in certain operations, there is a very considerable amount of splashing; but such splashes as are formed rapidly fall to the ground and are not held in suspension in the air.

Our experiments have been on a more elaborate and detailed scale than those of M. Herman and the constancy of the results obtained in so large a number of trials compels us to contradict the conclusion of that investigator in respect to "gouttelettes plombiferous microscopique."

We may here draw attention to the experiments made by the Government Chemist, described in the appendix, page 37, to the Departmental Committee on the use of paint in buildings. Sir J. J. Dobbie states that the amount of lead carried off from the painted surfaces under the specially favourable conditions of his experiments must be described as negligible. "The total weight of lead we obtained from nearly 84 lbs. of paint only amounted to 1.45 mgms.; this is equal approximately to one part in

26 millions of paint used.'' Sir J. J. Dobbie does not suggest that this lead is present as a minute spray which might be held in suspension in the air.

Even supposing that such had been the case, the amount found by Sir J. J. Dobbie would, in the Herman experiments, have been equal to a total deposit of .001 of a mgm. of lead on the whole of the exposed papers. According to Herman, papers 1 to 13 showed lead distinctly, whilst on 14 to 17 feeble indications were obtained. Ignoring 14 to 17, we have 14 papers numbered 1 to 13; presuming these to have collected all the lead in the area occupied by all the papers, each of the 14 papers would contain .0007 mgms. of lead, an amount which we are convinced it is impossible to detect by any known means of analysis. Indeed, employing the utmost refinement, it is not possible to detect less than 50 times this amount with any certainty. The absence of lead in papers, 18, 19, 20, is curious, in view of M. Herman's statement that he found a volatile compound of lead produced and absorbed by paper in his earlier experiments: if such a compound existed, it should have been found in papers 18, 19, 20, and its absence necessitates some explanation.

Summarised, the experiments on splashing have demonstrated that the quantity of splash produced is much greater in stippling than in ordinary brush work and is much increased when irregular surfaces are painted. Fluid paints give rise to greater splashing, as also does smoothing up of surface. In overhead horizontal stippling, the painter is exposed to splash but simple means can be adopted to make the danger negligible. In the painting or stippling of vertical surfaces, over 95% of the splashes fall within 6 inches of the surface but the painter's mouth is 9 inches from the outer boundary of the stream of splashes. Painters do not inhale splashes. Paint splashes readily fall to the ground. The existence of a minute spray suspended in the air has been disproved.

Painter's Overalls.

The most serious danger arising from splashes of paint is the creation of dust, as oil paint falling upon the fabric of the overall loses its oil by absorption or drying and affords a brittle mass which readily cracks. In addition to splashes caused in painting, overalls may be splashed during the grinding or mixing of the pigment with oil or the thinning down of stiff paste to paint. The only remedy against this risk is the exercise of reasonable care. We have observed that splashes caused in these processes frequently appear on the overall sleeve from the wrist to the forearm. A simple newspaper covering which could be removed and destroyed would, in our opinion, prove a suitable protection.

The Government Chemist (appendices 32, page 69 of the Departmental Committee report), describes the results of an examination of overalls obtained from 24 painters, worn during a week of normal employment, in which he determined:

(a) Dust removed by beating.
(b) Fine dust in pockets.
(c) Lead remaining after removal of *a* & *b*.

As is to be expected, there was considerable variation in the result from individual overalls. The only satisfactory way of considering such figures is to investigate closely the highest figures and then regard the results as a whole. Forty garments were examined, the average total ''dust'' (*i.e.*, ''dust'' removed by beating and fine dust in pockets) per garment contained lead equal to 56 mgrm. PbO. The figure is of considerable interest in view of a similar inquiry made by one of us (C.A.K.) in 1912, when overalls of 12 painters engaged on general work were examined after having been worn for periods varying from 5 to 12 days, during the ordinary course of work.

The overalls were packed in large smooth paper envelopes, each bearing the name of worker, type of work on which he had been engaged and the time the overall had been worn since it was last washed. The envelopes as received were packed in an iron trunk so as to avoid severe handling in transit and to prevent shaking out and loss of dust. The envelopes were examined and, before opening them, it was decided to divide the garments into three lots based on the class of work on which the worker had been engaged, viz.:

Lot A.			
3 workers totalling	18	days on	old building work.
Lot B.			
5 workers totalling	$35\frac{1}{2}$	,, ,,	new building work.
Lot C.			
4 workers totalling	30	,, ,,	mixed work.
12	$83\frac{1}{2}$		

The garments were pinned out on a cleaned floor and dust sucked away by means of a Baby Daisy carpet cleaner, the funnel being slowly drawn over every part of the surface.

The filter bag of very fine texture material was carefully cleansed after each lot had been treated, the dust so obtained being weighed and then analysed for lead. The figures obtained were as follows:

LOT A.	grms.		
Dust weighed	1.438	containing	10.7% Pb.
LOT B.			
Dust weighed	2.873	,,	16.9% Pb.
LOT C.			
Dust weighed	1.853	,,	20.1% Pb.

calculated to white-lead, this means

	grms.	grms.		
A yielded	0.192	=0.0106	per diem	per worker.
B ,,	0.607	=0.0171	,,	,,
C ,,	0.464	=0.0154	,,	,,

Twenty-two garments in all were examined, representing 12 men engaged during a total period of 83½ hours. These figures give an average amount of dust, reckoned as PbO, per day per worker, of 12.9 mgrm. PbO—a figure similar to that obtained from 40 different garments by the Government Chemist, whose average per day per worker was 10.9 mgrm.

The two inquiries were wholly unconnected and in view of the agreement are of value.

WASHING OF OVERALLS: The question has been raised as to the risk of lead poisoning in the washing of painters' overalls and it has been suggested that soluble lead salts are produced which are readily absorbed through the skin. In order to investigate this point, the twenty-two garments above referred to were washed in hot clean water and thoroughly soaked; the garments were then scrubbed, using an ordinary scrubbing brush and soft soap; after which they were washed in a rotary washer. No soluble lead could be detected in the wash waters. The lead removed in the washing process totalled 22.3 grms. of which 10.8 grms. were found in the lather and 11.5 in solid matter which had settled out from the wash waters.

There is no risk of lead absorption from soluble lead compounds in the washing of painters' overalls; the only risk is that arising from dust prior to the overalls being wetted.

DUST.

It is clearly recognised that the chief cause of industrial lead posioning is dust. Nothing could be more definite on this point than the opinion of Dr. Legge, H.M. Medical Inspector of Factories, as expressed in the Annual Report of the Factory Inspector for 1918:

> "On the practical side little is to be learned as to how lead poisoning is caused and it can be taken as axiomatic that all risk lies in inhalation of dust or fume. These removed or prevented, there would be no lead poisoning."

In view of this very explicit statement, it is necessary to investigate the details of the painters' occupation and to ascertain in what circumstances he is exposed to dust; it is found that the following are dust producing processes:

DRY SAND-PAPERING: The painter smoothens painted surfaces by sand-papering and the operation is applied to both old work and to intermediate coats.

Large quantities of dust are produced in this operation, as is well-known to those who have interested themselves in the matter. It is questionable, however, whether those actually engaged in the operation do appreciate the risk they run. We recently had a room dry rubbed down, making no remark: we found that the painter was wholly indifferent to the fact that his hair was powdered white and that his tracks were visible over the floor of the room.

In Appendix XIII. of the Home Office Report, Mr. Duckering, H.M. Inspector of Factories, gives the results obtained in a large number of determinations of the lead dust contained in the atmosphere in the vicinity of the mouth of workers engaged in dry rubbing down of painted surfaces. Some astounding figures are quoted. A concentration of 1025 mgms. of lead per 10 cubic metres of air was discovered in one instance, where a wheel was being dusted after the dry sand papering of a coat of quick drying lead paint. This concentration is over 400 times greater than the safe limit; the figure is abnormally high but, speaking generally, the figures obtained are far beyond the safety limit.

Mr. Duckering's results were obtained in investigations in factories and he was principally concerned with the air of coach painting shops in which dry rubbing down was practised. He does not appear to have made any investigations of dry rubbing down, as practised by English House Painters.

Dr. I. Kaup gave evidence before the Home Office Departmental Committee, as to the comparative quantities of lead in the form of dust found in Austria to be present in the air of rooms in which painted surfaces were respectively dry-rubbed and dry pumice-stoned; the quantities varied from 1 to 25 milligrammes of lead per 1,000 litres of air, *i.e.*, 10 to 250 milligrammes of lead per 10 cubic metres of air. These figures amply demonstrate the danger of the process.

Many painters imagine that no dust is created in the dry rubbing down of *recently* painted surfaces; we have therefore made a number of experiments in order to determine qualitatively the effect of age of films on the production of dust.

The experiments were made in a darkened room through which a strong beam of light was passed; the experimental surfaces were rubbed down above the beam of light, so that the dust, if any, would be detected. Surfaces one day, two days, three days, one week, one month, two months, six months, twelve months, two, three, four and 10 years old which had been painted with white-lead were rubbed down. It was found that the amount of fine dust created varied not only with the grain of the sand-paper but with the age of the paint film. The harder the film, the more dust is produced.

Indoor films do not appreciably alter in hardness after about three months and the behaviour of a three month old film appears to be similar to that of a film ten years old. Up to three months, in the case of an ordinary glossy paint, the amount of fine dust produced increases with age under the same conditions of rubbing. With soft films, there is a tendency for the paint to mat together and form comparatively large pieces, which fall rapidly; yet fine particles of dust, which remain suspended in the air, are produced even in rubbing down glossy paint one day old.

In the case of flat, quick drying paints, we would fix the hardening period in some cases at as little as one week. It is obvious that flat paints, depending for their effect on shortage of oil, can only give films capable of producing large quantities of dust. In these circumstances, in view of the danger, we are of opinion that the abolition of dry sand-papering is essential. It is important to note that the dust created by the rubbing down of any dried films, consists largely of the paint material and not, as has been suggested, in the case of new films, wholly of dust from the sand-paper employed.

We propose at an early date, to make a full inquiry into the question of dry rubbing down from a quantitative point of view. Certain aspects of the question demand elucidation; in particular the quantitative relations between age of film, fineness of sand-paper and composition of dust. In the latter connection, the figures of Mr. Duckering are of interest, owing to the small quantity of lead discovered by him in the dust created in dry rubbing down of surfaces painted with white-lead.

Chipping or Scraping off Old Paint. Both these operations give rise to dust; provided the work is not too lengthy respirators may be used with advantage.

Dust from Dry Pigment. A certain amount of dust is produced through the handling of dry pigment. We would gladly welcome almost complete abolition of the handling of dry pigment by the painter, as it is unnecessary. In point of fact, the pigment can be incorporated in an oil medium much more efficiently by the mechanical means in the hands of the paint manufacturer. The practice does not obtain so much in England as on the Continent and we were surprised recently to see a Continental inquiry in which white-lead in a fine powder was demanded in the place of lumpy white-lead, because "painters preferred the finely divided material, as it could be more easily incorporated with oil." We are convinced that an unnecessary risk is incurred by the practice of drying white-lead before grinding it in oil. The bulk of dry white-lead manufactured is ultimately made into paint. It is well known that white-lead can be effectively ground in oil, starting from a water-wet paste. The present practice means that two classes of workers are unnecessarily exposed to risk from lead, viz.:

(1) workers engaged in the manufacture of dry white-lead;

(2) workers engaged in grinding white-lead into oil paste.

We feel that this is a matter which should long ago have received the attention of the Government. The same position obtains with poisonous compounds other than white-lead: it is not uncommon to find the manufacturer drying a product which is wetted by the user immediately he receives it,

SOILING OF HANDS. Hands are soiled in the process of stopping cracks and irregularities with a stiff paste filling, by splashes created during the grinding or mixing of the pigment in oil, and in the thinning down of stiff paste to paint.

It is now agreed that lead is not absorbed through the skin: in these circumstances, the danger lies solely in poisonous material being carried to the mouth during smoking or eating.

Soiling of hands must be regarded as inevitable; the remedy is personal cleanliness.

VAPOURS FROM THE DRYING OIL.

UNSATURATED ALDEHYDES. It has been suggested that when white-lead paint dries, unsaturated aldehydes are formed and that the inhalation of these products causes symptoms which have, in the past, been confused with those of lead poisoning. The production of such compounds was supposed to be a property peculiar to white-lead, and not shared by its substitutes.

This matter was fully dealt with by the Government Chemist, by Dr. Goadby and by ourselves. The evidence of the Government Chemist is absolute from a quantitative point of view. His numerical results are given in appendix 31, where it is shown that the production of vapours is not peculiar to white-lead; the vapours are produced in almost identical quantity by all paints during drying, further, the products are substances which are necessarily produced during the drying of the oil.

Experiments with Animals, carried out by Goadby, Oliver, Moore, Oldershaw and Williams, have shown that when submitted to such vapours during a considerable period they remain perfectly healthy. Gardner has demonstrated the pronounced antiseptic properties of such vapours and their value in house painting. The subject can be dismissed from the literature of paint hygiene.

CARBON MONOXIDE. It has been stated that white-lead paint, when it dries, gives rise to a minute quantity of carbon monoxide and it was suggested that this carbon monoxide was a serious source of danger. The subject has been dealt with by one of us (C.A.K.) and the experimental method on which the assertion was made has been shown to be fundamentally unsound. This risk also can be dismissed.

INJURY THROUGH THE USE OF CAUSTIC PAINT REMOVER. Certain paint removers are caustic in character and are liable to cause irritation of the skin, if the hands be left too long in contact with the materials.

GENERAL CONSIDERATIONS.

In our inquiry, we have endeavoured to deal with all points of importance connected with painting and in describing the results to make clear the intricacies of the problem the industry presents.

Our study of the risks incident to the painter's occupation serves to show, in our opinion, that the position to-day is in no way different from that which prevailed in 1913.

We would urge, in the first place, that the only logical course, in future, will be to speak of "paint poisoning" rather than of "lead poisoning" whenever the occupational disorders of painters come under consideration.

Sir Kenneth Goadby, in his recent paper, gives a graph showing the number of fatal cases *assumed* to have been due to Lead Poisoning in the Lead-using Industries generally, during the period 1900-20. In no year did the number exceed 50 and it was usually far below.

No proof is forthcoming that the cases reported in the painting trade were properly returned as the result of *lead* poisoning; it is all but certain that a majority were in no way attributable to lead. The medical profession, at present, simply cannot diagnose *lead* poisoning with any degree of certainty: it is well known that, until recently, symptoms in no way due to lead were at once regarded as *lead* poisoning, if the subject happened to be a painter; even the much talked of blue line is not significant of lead alone.*

The medical profession, we fear, cannot be trusted in these matters, especially now that its eyes are so over-educated in the class-room. In fact, the limited outlook of the practitioner has been the subject of comment recently by Sir James Mackenzie, the noted authority not only on heart disease but also

* Sir Thomas Oliver, who is well-known on account of the service he has rendered in diminishing industrial disease, in his recent special address at the meeting of the British Medical Association in Newcastle, speaks of case within his personal knowledge in which death, certified as due to lead poisoning, was proved by post-mortem examination to be caused by malignant disease of the intestine.

He definitely stated, too, that the so-called lead poisoning of painters requires further elucidation and even asked the question: "Are the symptoms always and really due to lead?"

The President of the Association, it may be added, referred to the difficulty the practitioner has in arriving at a decision unless a post-mortem be held. (See *British Medical Journal*, July 23rd, 1921.)

on the application of scientific method in medicine. We quote the following from the opening paragraph of his address to the profession :*

> "My object is to demonstrate that the conception of medical research which is dominant to-day is so immature and imperfect that it renders fruitless much of the research work.
>
> "Never in the history of medicine has there been such activity as now and there never was a time when it was more necessary to have a clear perception of aims and method, especially as great schemes are being launched in legislature, in research and in education. If these schemes be based upon immature experience and imperfect knowledge, the progress of medicine may be hampered for generations."

Not only the progress of medicine but that of industry may be stayed by inconsidered action, inconsidered because based upon knowledge so slight that it is not worthy to be called knowledge.

Sir James Mackenzie, in his address, spoke of the difficulty even of knowing what are common diseases. One fact that came out on inquiry, he says,

> "was that the impression that great progress had been made in recent years was scarcely justified, so far as the recognition and prevention of disease was concerned. We found that discoveries of the origins of common diseases were so few during the past fifty years that we had difficulty in recognising any advance. A little consideration revealed the reason."

Certainly this is true of lead poisoning. Recent investigations have brought out irresistible evidence that there are numerous important differences between the symptoms exhibited by painters and by other workers whose sole occupational risk is exposure to white-lead, not to paint.

> (*a*) Acute kidney symptoms are common amongst painters, whilst uncommon among workers in white-lead factories; it is, therefore, probable that turpentine is the cause of the incidence of Bright's Disease among painters being above the average.
>
> (*b*) The prevalence of gout among painters and the absence of this symptom in white-lead workers, according to Goadby, is probably to be explained in a similar way.
>
> (*c*) Headache is an early symptom in cases of so-called lead poisoning amongst painters; in cases of lead poisoning by inhalation of lead dust, it is a late and grave sympton.
>
> (*d*) Goadby considers that the alteration in the blood produced by turpentine explains the chronic anæmia often seen in painters.
>
> (*e*) Arterio-sclerosis resulting in increased blood-pressure is more prevalent amongst painters than amongst white-lead workers; and this difference is ascribed by Goadby to the use of turpentine and its substitutes.

We have shown, by actual measurement, that the painter may inhale the vapours of the volatile thinner present in paint in sufficient quantity to produce toxic results. All thinners are toxic when inhaled in sufficient amount and the long continued inhalation of their vapours must have evil results.

Yet in none of the inquiries hitherto undertaken have the occupational disorders of the painter been seriously regarded as due to anything but lead. All other sources of danger have been disregarded, so that unfortunately a false sense of security has been given to the worker, who, if taught at all, has been taught only to take precautions against lead. In no case has the acknowledged difficulty of diagnosis been deemed even worthy of record, let alone of study. It is indeed, a case in which the physician must heal himself.

The English Departmental Committees had an unique opportunity of thoroughly investigating the problem of the painters' occupation in a scientific manner but failed entirely to appreciate the significance of the evidence it received. In particular, we call attention to the fact that lead poisoning is practically unknown among Scottish painters, as shown by Dr. Legge's statement in evidence :—

> In the whole of Scotland there are only 20 cases—12 in Glasgow. I attribute that not to what might be thought to be the reason—but to the fact that it is a stone country and consequent absence of outside painting. Certainly in Edinburgh lead poisoning is practically unknown. Those figures for the five years 1906-1910.

The Committee does not appear to have been at all impressed by this most remarkable pronouncement and their disregard of an obvious line of inquiry is striking testimony of their unscientific attitude towards the

* "A Defence of the Thesis that the opportunities of the general practitioner are essential for the investigation of disease and the progress of medicine." By Sir James Mackenzie, M.D., F.R.C.P., LL.D., F.R.S., Consulting Physician to the King in Scotland. Director of the St. Andrew's Institute of Clinical Research. Consulting Physician to the London Hospital. (Being a Lecture delivered at St. Mary's Hospital, in the Institute of Pathology and Research, during the course on Pathological Research in its Relation to Medicine.) *British Medical Journal*, June 4th, 1921.

question under consideration. A wonderful opportunity for investigation was presented: "Lead Poisoning" was shown to be practically absent amongst the painters in Scotland; the opportunity was not taken to ascertain why.

The explanation given by Dr. Legge is obviously inapplicable. London alone is a city of stucco, requiring constant painting; in most other towns there is little external painting. The immunity of the Scotch painter is far more likely to be the immunity intelligence provides and cannot well be due to other circumstances. That the English Departmental Committee did not regard Dr. Legge's evidence as an incentive to a proper inquiry is sufficient indication that their deliberations were not informed by a scientific spirit.

In short, the many problems presented by the painters' occupation demand thorough study, if they are to be grasped and solved. It is obviously impossible to decide so serious an issue as that involved in the prohibition of white lead at a discussion, lasting only a few days, by an inexpert International Conference, in a foreign country. The whole problem, so far as this country is concerned, is a domestic one: it can only be rightly judged on our own practice.*

In 1913, we made the following statement, which we would reaffirm:

> "It should be possible for a Society such as this (the Society of Chemical Industry) to help in promoting the promulgation of a code of industrial ethics. The public will expect the introduction into the code of articles protecting them more than is the case at present against the use of unfit materials, against the bold and unblushing advertisement of rubbish.
>
> "The special question we should raise is whether it be not desirable to determine by collective action what are truly fit materials for painters' use—whether it be not to the interest of the trade to promote systematic inquiry which will make it possible to offer sound advice, if not to lay down rules for the general guidance. The Americans are already alive to this necessity and have conducted extensive inquiries with paints. There are very many problems awaiting solution."

To summarise our case. We would ask whether we are to write ourselves down as an intelligent people or as one that cannot be trained and trusted to take charge of its own interests, free from bureaucratic control? If there is to be legislation, let it be the outcome of considered scientific attention, not of entirely partial treatment.

Idealists, sentimentalists, freaks, faddists—call them what we may—will always be with us: let us at least, as a nation, pay ourselves the compliment of believing in a background of common sense as our heritage.

Life is subject to many accidents but none the less we regard it as on the whole worth living and put up with our mischances. If we are to prohibit everything which has an element of danger in its use, we shall reduce life to so dead a level of dreariness that it will not be worth living. We can have no objection to the good being good and severely continent, if they will but allow us to admire them from a respectful distance; most of us, being wicked, cannot but crave that we be left some latitude of enjoyment.

The United States, in 19 months of War, lost 48,000; during the same period, 91,000 persons were killed on the American highways, 25,000 of these being children of school age. It is scarcely probable that the use of the automobile will be interdicted—as no sentiment, no ancient feud, rages round its use and abuse.

In the past five years, 160,000 forest fires in America have been the cause of the destruction of timber worth £17,000,000 as it stood. It is asserted that 80 per cent. of these fires were caused by carelessness on the part of individuals and could easily have been prevented. We have no indication as yet that the use of fire by our American cousins will be interdicted.

To get rid of all the risks to which the painter is subject, we must get rid of paints altogether—a noxious ingredient, for which there is no substitute, being common to all. In fact, if prohibitionists have their way, we shall be forced not only to wear sackcloth and ashes but only to whitewash our houses.

The country is sick of bureaucratic and legislative interference. It is waking up to the fact that we must be free to develop and use our intelligence: that we must learn to work together and live together—or go under. No single mind, however able, sitting in an office and influencing a Com-

* The Home Office Departmental Committees recommended the Prohibition of the use of White-Lead. The evidence that such action is *practicable* is almost wholly evidence tendered by the Office of Works, based upon an incomplete inquiry into the use of various paints of unknown composition: one of us has called in question the validity of the tests on which reliance was placed. We challenge the Office of Works to-day to deny, as a fact, that zinc oxide paints, in particular, have failed where white-lead has given satisfaction.

mittee can be sufficiently alive to the many problems affecting even the simplest of our practices to lay down limiting and bounding rules.

We must live and let live—seeking always to make the conditions of living more healthful, less distressful. We shall best do this, not by compulsion but by raising the general level of intelligence, whether of masters or men: the former have often been the more ignorant.

We have endeavoured to show what are the disabilities under which the painter labours and their magnitude. Taking these into account, it is only necessary to bring home to him the fact, that if he will but take certain elementary precautions he has little to fear. The evils arising from dust may be overcome by substituting wet for dry rubbing down: on occasions when this is not possible, the operation may be rendered harmless by wearing a simple respirator over the nose and mouth. The effects of splashing during overhead work may be avoided by a simple screen worn over the mouth. The effect of turpentine and other vapours is to be avoided by working in a properly ventilated apartment. Care should be taken of hands and clothes and paint neither eaten nor smoked.

The dangers have been exaggerated: the painter's occupation is not an unhealthy one. The class is largely migratory and the workman is rarely occupied on the same kind of work during a long period. In factories, where the occupation is more uniform, supervision can be more easily exercised, and the necessary precautions observed. It is to be remembered also, that the welfare measures introduced of late have had a great effect in teaching workers to be careful.

Actual experience in this country proves this to be the case as is shown by the remarks of Dr. Collis (H.M. Medical Inspector of Factories), in the Annual Report of the Chief Inspector of Factories and Workshops, for the year 1910 (Cd. 5693, p. 175); dealing with coach painting, speaking of his visits to three large railway works, he remarks:

> At the third works lead paint is used generally, but great care is exercised to prevent plumbism, no surface covered with lead is sandpapered, no burning off of lead paints is done, there is good lavatory accommodation and an excellent dining room and kitchen, where food brought by the men is cooked, are provided. The general health of the men is good.

Such a statement leaves no question as to the efficiency of hygienic control in rendering the operation of coach painting a healthy occupation. The most important lesson now to be learnt by workers, is that there should be proper choice of food—that improper feeding, food improper in quality rather than in quantity, is at the root of much industrial ill-health.

The attempt to shut down an entire industry, because its practice is not entirely without risk, is foredoomed to failure: no industry, no occupation, could survive such a test. Medical men often kill us—yet as they sometimes cure us, we shall continue to consult them, if only because of the mental and moral satisfaction we derive from their seeming wisdom. Sir James Mackenzie has made it clear that their gift of prognosis is so slight, that they can see so little ahead, that we can neither rely on their promises nor attach weight to their dire forecasts.

The claim of the White-Lead Industry is, that it is one which renders great public service and a service which no substituted industry can well render. The decoration of our houses has always been a costly business and of late the cost has been all but prohibitive—we shall, therefore, desire to use materials that are lasting in preference to those which have but a short life, especially under external conditions.

The Germans, we know, very skilfully used all kinds of *Ersatz* materials during the war—but we still prefer honest leather to any substitute: probably it was used by primitive man and it has stood the test of time.

White-Lead is not used without reason. Paint is a complex material but one thing is certain, that by the interaction of white-lead and oil, a material is formed which has special properties not possessed by the products obtained by the use of white-lead substitutes. White-lead paint has stood the test of time. The Lighthouse and Naval Authorities and those who have to do with great iron structures, we believe, are particularly alive to the value of lead paint as a protection against atmospheric attack.

In fact, one may transfer from Wine to White-lead Paint, the matchless sentiment phrased by Mr. George Saintsbury:

"On those who would deprive us of it, let the curse of Nature rest."

Industrial Hygiene, as a science, must be constructive. Not overlooking the risks, we have to avail ourselves as far as possible of all things—to minimise the evils and elevate the advantages attending their use. Slaves we cannot be: those who would make slaves of us must be waved aside, as stumbling blocks in the path of progress.

DISCUSSION.

SIR KENNETH GOADBY, K.B.E., D.P.H. (Specialist Medical Referee for Industrial Poisoning, London and Home Counties), said he was very much interested in the subject with which the paper dealt from the scientific standpoint, and welcomed the careful inquiry the authors had made into the application of measurement to questions of supposition. Directly measurement was introduced any fallacies were detected. The authors had very carefully analysed splashes of paint and had found a method of determining the size of those splashes. Those who were interested in the prevention of lead poisoning had found, after a good deal of experiment, that practically all the lead poisoning that occurred amongst lead workers, amongst painters and even to a large extent amongst plumbers was caused by dust. The fact formed the basis of all the present legislation on the prevention of lead poisoning and of all the extraordinarily good work that had followed from the Home Office study of the question of dust as a source of poisoning, and an enormous decrease in lead poisoning had taken place in all those industries where dust could be prevented, yet in the curious document recently published by the International Labour Bureau, to which the authors had referred, dust was dismissed in a few words as a matter of no importance. The document stated that lead poisoning was not caused by dust but by other things, and the writers of the document actually had the effrontery to ask the English Government to agree with their contention and to support certain propaganda they put forward on the basis of denying the experiments upon which lead poisoning had been combated for the last fifteen years. With regard to the question of dust, it was well known that the human lung was composed of a piece of apparatus very like a bellows, and there was a pipe, like the pipe of a bellows, which communicated with the mouth cavity in one direction and with the nose in the other. There was provision made in the nose and the mouth for dust particles to be caught when air was inhaled. Just inside the nose there was a number of small hairs, which acted as a filter, and the inside of the nose was arranged anatomically in such a way that the draught did not go straight down the back of the throat, but curved round and round, so that the dust was deposited on the moist surfaces. Even then the air had to turn another corner before it got down into the lung itself. A great deal of importance attached to the question of the size of particle which could pass along the airway and not be deposited before it reached the lung. To get into the lung along the wet tube and reach the place where it could be absorbed and cause poisoning the dust particle had to be very small. In the disease known as "grinder's rot," which was caused by particles of silica getting into the lungs, the particles had to be very small indeed—25/1,000in. was a large one—and microns had to be used to express the size of them. Mr. Klein had shown that a great many of the particles of paint splashes were hundreds of times larger than any particle that would be taken down the moist tubeway of the lung. That was very important, because it enabled one to ignore as a source of poisoning a factor upon which there was a certain divergence of opinion. With reference to the graphs which he gave in the paper he read before the Society in May and to which the authors had referred in the present paper, the statistics were those given by the Home Office. He did not say they related to cases of lead poisoning as now known, but they were figures of lead poisoning as published by the Home Office. Dr. Legge had stated that many of the cases of lead poisoning amongst painters which came up for review had to be deleted from the list because the diagnosis was not certain. He was pretty sure that a very large proportion of the cases that were attributed in those statistics to poisoning with lead were not cases of poisoning with lead at all, but it was a very difficult matter to prove they were not cases of metallic poisoning. The way in which cases of lead poisoning in painters were diagnosed was rather different from that which obtained in the case of other industries, particularly those industries which were working under the special rules of the Home Office. In white-lead works, in painting works which were carried out in a factory building and which came under the Factories' Act, and in the manufacture of paints and colours generally, and shipbuilding, and so forth, the cases were seen by a specialist. The certificate was not given by a general practitioner, whose knowledge of lead poisoning might or might not be good, but, whether good or bad, it was frequently his unfortunate duty to have to state whether or not a man who was one of his own private patients should receive compensation. It was a little difficult for a doctor in a small country practice, in a district where he was well known to everybody and where there might be a certain amount of discussion as to whether a certain man was suffering from lead poisoning or not, to say the case was not one of lead poisoning when there was no definite proof to that effect, and

he was very often obliged to give the man the benefit of the doubt. Another point in that connection which deserved more attention than it at present received was that medical men were not trained in the recognition of industrial disease. That was a matter that hardly concerned the present meeting, but what did concern it was the question of the volatile substances to which reference had been made in the paper. The fact that volatile substances given off in certain occupations might produce disease was in some ways more or less new and in other ways it was old. With respect to turpentine, that had been known for some time to be an irritant, but the diseases which had been ascribed to turpentine did not have symptoms which would be confounded with those of lead poisoning. In the Report of the United States Commission on Occupational Diseases, to which the authors had referred, attention was called to affections of the hands, dermatitis, and so forth, common to every form of irritant and differing according to the susceptibility of the individual. Then there were diseases of the kidney and cases of severe headache, and in a number of cases in New York and in the shipbuilding yards of this country there were cases of sudden vertigo with giddiness and possibly stupor for a short time, following the inhalation of paint vapour. That was well known, but what had not been so generally known were the curious secondary effects of turpentine vapour in small and long continued doses, not in a large dose, and it was that particular question that had been interesting him recently. In 1911 the Report of the Commission on Occupational Diseases to which he had referred stated that kidney disease and troubles of that description were associated with painters, and now he found, on examining the painters in this country who were not using white-lead, that they showed symptoms which might be attributable or related to kidney disease when the people actually working with white-lead did not show such symptoms. That was very suggestive. But in connection with volatile compounds there was something further to consider than merely the question of turpentine. "Turpentine" was a term used in rather a generalised sense to mean all the volatile substances used for thinning paint. Amongst those there was at the present time a number of substances which would cause far more disease than white-lead had done if they were introduced on a large scale. The last point to which he wished to refer was the question of splashing, which had always been a little difficult to understand. There appeared to be very little reason indeed now for supposing that the small particles of lead thrown off from the brush were likely to gain an entrance into the lungs, and he thought that had disposed of one of the serious objections to the use of lead paints. The experiments that had been made also showed that the painter was much more subject to inhaling the volatile compounds of his paint than to inhaling the solid particles of it. He wished to congratulate the authors of the paper on a contribution which would very materially help in the medical question of the prevention of lead poisoning.

MR. NOEL HEATON wished to express his admiration of the extremely able way in which the very tedious subject had been worked out. In referring to the apparent volatility of lead discovered by M. Herman, of Belgium, the authors gave as an explanation the presence of copper in the filter paper used and mentioned the dendritic crystals of copper which were developed in the paper. Curiously enough, he had come across an article published in *Nature* over twenty years ago, drawing attention to the same point. With regard to the very elaborate and detailed experiments made on the question of splashing, Mr. Klein had shown a slide giving a suggestion for protecting the painter's overalls from the splashes when they did fall by means of covering with newspaper. That was an excellent idea, but it had occurred to him that there might be some difficulty in inducing painters to adopt the paper "over-overall," as it might be called, and he would like to know whether the painter expressed any views on the subject and whether he found any difficulty in painting with a double allowance of overalls. He took it that all the records of splashing given referred to splashing produced by a skilled painter who knew how to use the brush. It was well known that there was a very great difference between the amount of splashing produced by a man to whom the brush was a proper tool and the amount produced by a man who was what might be called an alleged painter. That was a very important point, because the authors had proved most conclusively that the expert painter would scarcely suffer at all from trouble owing to splashing, and it was amongst the inexpert painters that any trouble possible in that connection was likely to occur. It was, therefore, very important to insist on the education of the painter at the present time and to limit as far as possible the number of inexpert painters that were employed. That would be beneficial to the painter himself and would also exercise a favourable influence on the statistics of poisoning, because it was amongst the inexpert, he thought, that nine-tenths of the trouble arose. Any practical decorator would probably say that so long as he employed thoroughly practical and expert painters he had very little trouble with sickness. Not only did the inexpert painter hurt himself, but he wasted a lot of time and material, so that the more the painting craft was confined to the man who really knew his job the better it was for all concerned. With regard to the question of whether all the cases reported as lead poisoning were really cases of lead poisoning and as to how far the question of poisoning by volatile

thinners had to be taken into consideration, he might mention two cases that had come to his own notice during the past year. One was the case of a man employed at the factory where he was himself engaged, who had been employed in grinding the dry base of the enamel. The man went sick one day, and a report was sent to him that the man was suffering from plumbism. He was rather staggered at that, because, as a matter of fact, the man had not touched white-lead for weeks, so he went to see the doctor about it and found there was no evidence at all that the man was suffering from plumbism. It was simply a case of lumbago, and the only reason why the doctor said it was plumbism was that the man told him he was working in a paint factory and the doctor immediately assumed that the man was using white-lead, when as a matter of fact he was not using it. He thought a man like that could "pull the doctor's leg," as often happened during the War in cases of supposed gas poisoning. The second case he wished to mention was the following:—The firm he was with supplied some enamel to a well-known firm of scientific instrument makers in the Midlands, and some time afterwards that firm wrote and asked whether his firm could guarantee that the enamel supplied by them for the special purpose in question was absolutely free from lead. The letter was referred to him for reply, and as he had not the faintest notion why the inquiry was made he had to be very careful in answering it. He did not know exactly how far the scientific instruments made by the firm ranged, and it was well known that for certain purposes it was necessary to have an enamel absolutely free from lead—for instance, if it was to be brought into contact with certain types of high explosives. He therefore replied to the letter to the effect that his firm could not guarantee the enamel to be absolutely free from lead, but they could guarantee that lead was not present to the extent of more than .01 per cent., which was in the form of driers added to the enamel. He also said that if it was necessary for the purpose in question to remove that trace of lead, his firm could do it. Nothing more was heard about the matter until some weeks afterwards, when he called to see the firm, as he was in the neighbourhood on other business, and asked them why they made the inquiry and whether they wanted an enamel that was absolutely free from lead. They replied "No, we were quite satisfied with your answer. The reason we made the inquiry was that we had a man who went sick and he was certified to be suffering from lead-poisoning. The only possible way he could have got that lead poisoning was by the use of this enamel; he was employed in spraying the enamel on to the various appliances we use. We therefore wrote both to you, who supplied the finishing enamel, and to another firm who supplied the undercoating which was put on first, and that firm replied in exactly the same way as you did." The puzzle was how that man got lead poisoning and could it be lead poisoning, considering that all the materials used were to all intents and purposes free from lead. The presence of .01 per cent. could not be sufficient to give a man plumbism.

Sir Robert Robertson, K.B.E., F.R.S., said he could not claim personal acquaintance with the subject under discussion, but he would like to associate himself with the other speakers in congratulating the authors of the paper. Apart from the attention that had been called to the effect of turpentine, he thought the most important point in the paper was the quantifying of the mist effect caused by the process of stippling. The experiments in that connection and the measurements with regard to the size of particles that would cause trouble must go a long way to settling the point. One question which had not been dealt with in much detail was that of the rubbing down of paint, which he thought was now recognised as an evil, seeing that it had been proved on the medical side that inhalation through the mouth and not through the skin was the real danger. Just as the authors had succeeded in quantifying the size of the particles in the case of liquid paint, would it be possible for them to determine the average size, or perhaps the smallest size, of the particles produced in the dry rubbing down of paint? It had been suggested that the process of the dry rubbing down of paint could be rendered innocuous by the use of glass paper soaked in kerosene. He did not know to what extent that was practicable. At first glance it might appear that if the kerosene were of too high a boiling point it might persist too long and affect the character of the layer of paint which was afterwards put on, but personally he had no information. He did not know whether the authors, in the course of their experiments, had done any work on that subject, but it would appear to be important, in view of the considerable scare that had been raised with regard to the dust thrown off during the dry rubbing down, that the point should be determined as to whether the particles were of such a size as would do harm, and whether, if they were, it would be practicable to employ such an oil as would not have a detrimental effect upon the next layer of paint applied.

Prof. H. E. Armstrong, in replying to the discussion, said that with regard to Sir Robert Robertson's remarks a good deal could be said about the production of dust in rubbing down with paper or pumice: Mr. Klein and he had not made any special measurements of the amount. He supposed it would be possible to do so but thought the way to look at the problem was the practical way. It was recognised that dust was produced and

that it must be guarded against either by the use of respirators or by employing a wet rubbing down process. The oil method to which Sir Robert had referred had been used, he believed, in the United States but was not in favour in this country. He thought considerable care would have to be exercised in the choice of the oil, because otherwise the surface might be so affected that the paint would not adhere in the proper way. He wished to acknowledge the able assistance that had been rendered to Mr. Klein and himself by various chemists in the employ of the Brimsdown Lead Company, to whom they were greatly indebted in connection with their experimental work, namely, Mr. W. Hume, Mr. Hargreaves and Mr. Baker. As would be realised, the experiments on splashing had not been very simple ones to carry out and the assistance rendered by those gentlemen had been very efficient.

Mr. C. A. Klein, who also replied, said there were two points in the discussion to which he would like to refer. The first was raised by Sir Kenneth Goadby. When Sir Kenneth read the complete paper he would find that the authors had determined the quantity of turpentine present in the air at the mouth of a painter engaged in applying white-lead paint containing 5 per cent. of turpentine. In one case the air contained 3.2 mgms. of turpentine per litre of air breathed, and in another case 4.9 mgms. of turpentine per litre, figures which were stated by Lehmann to be toxic. Sir Kenneth Goadby, in the evidence he gave before the Home Office Committee, stated that a concentration of turpentine of 8 mgms. per litre produced symptoms of poisoning in himself, but did not name the period of exposure. With regard to dry rubbing down, the authors had dealt with the subject particularly with reference to the age of the film of paint. The common idea amongst painters was that if a paint film three months old was rubbed down fine dust, which, after all, was the dangerous dust, was not created. The authors found that a process of hardening took place, and that after three months almost any film could be regarded as sufficiently hard to produce a maximum quantity of dust when rubbed down, but even a film 24 hours old produced fine dust, which floated in the air, and that dust was a source of danger. With new films much of the paint left the surface and fell in clotted masses, but fine dust was produced which contained lead, and was, therefore, a source of danger. The only method that could be adopted to prevent true lead poisoning—not the lead poisoning in inverted commas referred to by Prof. Armstrong—was the abolition of the process of dry sand-papering.

On the motion of The Chairman, a hearty vote of thanks was accorded to Prof. Armstrong and Mr. Klein for their valuable paper and the meeting terminated.

OBITUARY.

Sir Samuel C. Davidson, K.B.E.—Sir Samuel Cleland Davidson, manager of the Sirocco Engineering Works, Belfast, died at Seacourt, Bangor, Co. Down, on August 18th, in his seventy-fifth year. Born in Belfast he was trained as an engineer in that city, and as a young man went to India, where he became proprietor of a tea estate. Returning to Ireland he started the Sirocco Works for the manufacture of plantation machinery he had invented in India. The number of engineering patents he took out was very large, his inventions including the well-known Sirocco fan, which has been of such great benefit especially in improving factory and mining conditions, and a process for the making of raw rubber. He was appointed a Knight Commander of the Order of the British Empire, on the occasion of the Royal visit to Belfast in June, but owing to the state of his health could not attend the investiture in the Ulster Hall. He was a Fellow of the Royal Society of Arts, having been elected in 1890.

George Archibald Douglas Stuart, I.C.S.—The death of Mr. G. A. D. Stuart, I.C.S., occurred at Madras on August 8th. Son of the late Mr. G. H. Stuart, Director of Public Instruction in the Southern Presidency, he was born in 1880, educated at Emmanuel College, Cambridge, and joined the Indian Civil Service after the examination of 1901, being posted to Madras. He became the local Director of Agriculture in 1917 on the appointment of Mr. D. T. Chadwick, C.I.E., as Indian Trade Commissioner in England, and in 1919 was selected to officiate as Agricultural Adviser to the Government of India and Director of the Research Institute at Pusa. He was elected a Fellow of the Royal Society of Arts last year.

CORRESPONDENCE.

TIDAL POWER

I should like to know whether a tidal power scheme on the following lines has ever been tried, and if not, whether it is considered practical:—A power plant to be built at sea, at the lowest possible tide, and the power or weight derived from the high and low tides utilised for the compressing and releasing of steel plates, or other device (to be designed), by which rotary motion might be obtained?

The difference in the weight of the water at high and low tide, at the lowest tide point, must be considerable.

I do not consider the usual methods adopted of trying to get power from the inflow and outward flow will ever be a commercial success.

D. R. Broadbent.

RESOURCES AND TRADE OF THE YUNGAS DISTRICT OF BOLIVIA.

The Yungas region of Bolivia comprises a country of tropical and semi-tropical valleys lying to the north-east of the Cordillera Real, or main chain of the Andes. The Bolivian Yungas lie in both the Departments of La Paz and Cochabamba, but the Yungas of La Paz are much more highly developed than those of Cochabamba. In the former Department the district known by this name includes the Provinces of Nor and Sur Yungas and part of that of Inquisivi, and in the Department of Cochabamba contains the montaña region which lies to the north of the Cordillera Oriental.

According to a report by the U.S. Trade Commissioner in Bolivia, from which the following particulars are extracted, the region consists of deep valleys or gorges lying between precipitous mountains that are generally covered with a dense growth of vegetation. However, the vegetation on the northern slopes of these mountains is usually much heavier than on their southern sides. In some places high ranges of snow-covered mountains overhang warm valleys, where coffee and bananas grow in abundance. The altitude of the Yungas proper varies from about 2,000 to 7,000 feet above sea-level, but most of the cultivated area lies between 3,000 and 6,000 feet. There are numerous swift-flowing streams with a general north-easterly course to their junction with the main system of the Rio Beni, though some of the rivers of the Yungas of Cochabamba belong to the Mamore system. Among these streams are the Coroico, the waters of which reach the Beni through the Rio Kaka at Puerto Pando, and the Bopi, which is formed by the junction of the Rios Tamampaya and La Paz. The volume of these rivers varies greatly between the dry and rainy seasons, but at all times of the year they represent great possibilities for the development of hydro-electric power.

The climate of the Yungas is warm, and in the lower altitudes is even quite hot. Except in the bottoms of some of the valleys, where a certain amount of fever is prevalent, the climate is remarkably healthy. The dry and wet seasons are usually very definitely marked off, the months of heaviest rainfall being from December to March or April, which are also the months of highest temperature. Little or no rain falls during the so-called winter season, which extends from June into September. The rainfall, which is produced by the moisture-laden winds from the Amazon Basin coming into contact with the mountains, varies directly with the altitude. At Chulumani, which is about 5,500 feet high, the annual fall is about 40 inches. At the Neque Jahuira camp of the Yungas Railway, which lies at an altitude of 6,790 feet, the rainfall for the first three months of 1920 amounted to about 53 inches. The temperature at Chulumani varies between 64° and 88° F., but at the Rinconada camp of the railway, which is situated at 13,760 feet, the thermometer falls to several degrees below freezing, heavy falls of snow are frequent, and the weather is inclement throughout the year. On the descent into the Yungas from the divide the first trees are seen at Pongo, at an altitude of 8,900 feet, and the first orange trees at Chaco, at 6,225 feet.

The Yungas region is decidedly under-populated. The census of 1900 shows only 26,800 inhabitants for 14 of the most heavily settled cantons, and it is doubtful if the present population of the two Provinces of Nor and Sur Yungas exceeds 40,000 people. The complaint is heard in all parts of the Yungas country of the lack of hands for farm work. However, it is almost impossible to persuade the natives of the altiplano to emigrate to the Yungas, despite the superior natural conditions of that region.

Most of the inhabitants are Indians, the number of whites and of cholos, or mixed breeds, being relatively very small. Though the Yungas Indians speak Aymara, they have little else in common with the Aymaras of the La Paz highlands, and are quite different in physique and disposition, as well as in their customs.

The roads of the Yungas are surprisingly good in spite of the fact that their construction and maintenance are attended with great difficulties, owing to the contour of the country and the heavy rainfall. Because of the steep slopes of the mountains, in the sides of which the roads are cut, long stretches of road must be rebuilt after the rainy season. These roads, which are only suited for mule traffic, follow the valleys or the sides of the mountains, in some places at a height of 2,000 or 3,000 feet above the bottom of the valley, with a sheer drop from the side of the road. The roads are largely kept up by an association of the principal landowners of the district, known as the Sociedad de los Proprietarios de los Yungas. A toll charge of 10 centavos (about 2d.) is levied on all pack animals entering or leaving the Yungas. The proceeds of the road tax are also utilised for the maintenance of the roads.

The principal road of the region is that which leads from La Paz over the divide and down the valley of the Unduavi to a point where it sends off branches to the north and south. The first of these branches goes by Coripata to Coroico, the capital of the Province of Nor Yungas, and the other leads to Chulumani, the capital of Sur Yungas. A cut-off to Coroico from the main road has been closed because traffic over it interfered with the construction work in the railway. The distance from La Paz to Coroico via Coripata, about 93 miles, can be covered by mule from the end of the railway at the divide in about three days. The distance to Chulumani, about 81 miles, is about two and a half

days by mule. From Chulumani the trail leads over two high ridges for about 12 miles to the town of Irupana, from which point there are connections through the Inquisivi district with the Bolivia Railway at Eucalyptus, or by the La Paz River with the city of La Paz.

About 5,000 mules and burros pass over the La Paz-Yungas road every day. The road can be used by carts for about 30 miles out of La Paz, or to about 14 miles beyond the summit. Tenders were invited last year for the improvement of the road to the summit, so that it may be used for motor traffic. Farther from La Paz the road is only a mule trail, with grades of 30 degrees and over for considerable distances. The months of June and July are the best time of the year for visiting the Yungas. Travel during the rainy season is attended with serious inconveniences and at times is next to impossible.

Agriculture is the most important industry of the Yungas, but it is still carried on on a relatively small scale, owing to the lack of large extensions of level ground. Practically all the farming is done on the mountain sides, although some narrow strips of land bordering the streams and subject to inundation are cultivated. About Chulumani and in a few other parts of the neighbouring country there are large basins among the mountains, practically all of which are under cultivation, even to the very tops of the mountains.

The greater part of the land in the Yungas is held by a comparatively small number of owners, most of whom reside in La Paz and entrust the management of their estate to a majordomo. Though there are a few independent proprietors among the Indians, some of whom have accumulated fortunes in the coca business, the majority of the natives are tenants without any independent resources. Some of the Yungas estates have an Indian population of from 150 to 250 workers.

The cultivation of coca is the principal basis of the agricultural industry of the Yungas, and is also the most lucrative business of that region. There are no large plantations of coca, but it is grown on terraces, an acre or two in size, built up on the hillsides. These terraces are about 10 inches wide and are protected by a rampart of earth of about the same width and about 6 inches in height. The ramparts are generally faced on the outside with stones or with a rough cement. The use of terraces not only prevents the heavy rains from washing the whole plantation down the mountain side, but it tends to hold the moisture about the roots of the plants. The plants are usually set at intervals of from 6 to 10 inches. The unit of measurement for lands devoted to the cultivation of coca is the cato, which is equivalent to about one-fourth of a hectare, or 0.62 acre. Coca lands bring from 300 to 500 bolivianos (boliviano=about 1s. 7d.) per cato.

The coca plant is a shrub 2 or 3 feet in height, though, when allowed to mature, it reaches 4 or 5 feet. However, it is cut down to the ground before attaining that height, as the quality of the leaves deteriorates with the height of the plant. The young shoots are grown under a cover of dried banana leaves and are transplanted to the terraces. The plant begins bearing at two years, and continues for about 20 years. The leaf, in which lies the commercial value of the plant, is oval in shape and light green in colour; it is about 1½ inches long and about three-fourths inch wide.

Three or four crops of leaves are picked from the same plants during the year. Each cato planted to coca will produce from 7 to 14 cestos of leaves annually. (The cesto is equivalent to about 25 pounds. Two cestos make a tambor, which thus contains about 50 pounds of leaves.) All the coca is packed for shipment in units of 1 tambor. Of the coca production of the Department of La Paz, the Province of Nor Yungas produces about 37 per cent., Sur Yungas about 58 per cent., and Inquisivi the rest.

After the leaves are picked they are dried in the sun on a floor made of slabs of slate. They are then pressed into bales of uniform size and weight (1 tambor, or 50 pounds). The dimensions of these bales are about 20 by 14 by 12 inches. They are wrapped with dried banana leaves and burlap to protect them against the weather and rough handling. The coca is carried to La Paz by mules, each mule carrying a load of 4 tambores, or about 200 pounds.

The total production of coca in the Department of La Paz is about 3,700 tons annually. The production of the Department of Cochabamba is much smaller, the 10 tons of coca leaves carried by the Oruro-Cochabamba line during 1919 being a fair index of the yield of the Yungas of Cochabamba.

Coca is known chiefly as the basis of the anæsthetic cocaine, none of which is manufactured in Bolivia, though some is made in Peru Most of the Bolivian production is consumed within the country, where it is widely chewed by the natives of the plateau for its narcotic effects. The natives mix it with the ashes of the quinua plant, which serves as a condiment. Its use enables the Indian to go without food for a considerable time and work for long stretches without rest. However, its prolonged use deadens the nerves and other sensibilities of the organism, and is thus a potent factor in the degeneration of the Indian race of the plateau. The coca habit is also widespread among the inhabitants of some parts of northern Argentina and in certain districts of northern Chile.

There are no large plantations of coffee in the Yungas, but it is cultivated in small patches throughout the entire region, or the trees are planted as hedges along the roads or around

fields of other crops. Little care is given to the cultivation of coffee, and the trees are not properly trimmed or shaded. The first crop is generally picked at the end of 1½ or 2 years, and the trees continue bearing from 15 to 20 years. The usual yield is between 3 and 8 pounds per tree. The natives pick ripe and green green berries indiscriminately, so that careful grading is difficult. However, the berries are of good size and the coffee is of excellent quality, its aroma being equal to that of any South American coffee.

The cultivation of cacao has been little developed as yet, though parts of the Yungas are very well suited to its growth. In 1918, 1,889 kilos, to the value of 3,683 bolivianos, were exported from the Coroico district to Chile.

In spite of the lack of attention given to the trees, the quality of the Yungas oranges is probably unsurpassed in South America. They are of good size, though not so large as those of Bahia, extremely juicy, and of excellent flavour. Most of the production is consumed in La Paz, to which market they are carried on burros. The production of tangerines is also considerable.

Bananas are grown in large quantities throughout the Yungas, and are carried thence to La Paz, but their quality is generally inferior. Lemons and limes of very good quality are also grown.

Though the climate is suited to the raising of sugar cane, comparatively little is grown, and the small production is utilised in the manufacture of alcohol. Tobacco is also grown on a small scale. Corn is grown to supply the needs of the local population, as is also yuca, or mandioca, which is one of the staple articles of food of the natives of the region.

The Yungas region is not of great importance as a mining district, though the lack of good transportation facilities is responsible for the failure to develop such mineral resources as exist. Most of the deposits so far worked are situated in a range which rises above the Rio Taquesi, in the Province of Sur Yungas. The deposits of the Pichu district near Yanacachi are largely of tin ores and those of the Chojlla district consist of tin and wolfram.

Burros are raised for use as pack animals, but most of the mules used for that purpose are brought from Argentina. Though few goats are raised, there exists an unusually good field for their breeding, as large numbers could find food on the hillsides of the region. They are, moreover, greatly needed to furnish a meat supply for the local population, which suffers from a lack of variety in its diet and particularly from the lack of meat. The flocks of sheep are few and small, as the climate of the district is not so well suited to them as is that of the altiplano. Hogs do very well in the Yungas, but their numbers are limited to a few raised by the Indians. Owing to the lack of pasturage, there are almost no cattle in the Yungas, and meat is brought dried from La Paz. An experiment o bringing cattle from the Beni failed because of the great distance which it was necessary to drive them.

The Yungas towns are small and very backward in appearance. They are usually situated high up on the mountain sides or in some cases on the very crests of the mountains. The streets are all paved with cobble stone, and there is a considerable number of two-storey houses built of rough bricks and faced with cement. There is little accommodation for travellers. The most important towns of the region and their estimated population are: Chulumani, 2,500; Coroico, 1,800; Coripata, 800; and Irupana, 700. Other towns are Yanacachi, Villa Aspiazu, Chirca, Pacallo, and Ocabaya.

The total consumption of imported goods in the Yungas is comparatively small, as the population of the region would indicate. The principal goods in demand are cottons, flour, sugar, ordinary hardware—machetes, hoes, shovels, etc.—and such groceries as canned sardines and salmon. Nearly all the hardware and prepared foodstuffs sold are of American origin. Most of the local dealers go to La Paz to make their purchases, and generally deal in coffee and other local products.

GENERAL NOTES.

Industrial Chemistry.—The Société de Chimie Industrielle will hold a Congress in Paris, in October. There will be thirty-four *sections technique* representing the various applications of chemistry and some valuable discussions are anticipated. A reception of the members will take place in the evening of October 9th, and the opening meeting will be held on the 10th, under the presidency of Monsieur Dior, Minister of Commerce. On the 11th, the Minister of Agriculture, will occupy the chair at a Banquet in the Palais d'Orsay. A number of works will be visited on the 12th. An exhibition is being organised in connection with the Congress. The address of the Société de Chimie Industrielle is 49, Rue Mathurins, Paris.

Coccidiosis.—The Ministry of Agriculture and Fisheries has issued a leaflet (No. 364) on coccidiosis, a disease of various animals caused by the multiplication of a very small protozoan parasite. Amongst the animals most frequently affected are rabbits, poultry, feathered game, sheep, goats and cattle. The leaflet, which includes certain cardinal rules for controlling the disease, may be obtained on application to the Secretary, Ministry of Agriculture and Fisheries, 10, Whitehall Place, S.W. 1.

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All communications for the Society should be addressed to the Secretary, John Street Adelphi W.C. (2)

NOTICE.

EXAMINATIONS.

The results of the three stages of the examinations held from May 2nd to 11th have now been sent to all Centres. The printed results of the March examinations will be ready in a few days and will be forwarded to the Centres concerned.

The number of papers worked at the two examinations was 51,267. Of these, 8,125 were in the Advanced Stage, 1,141 first class and 4,183 second class certificates being awarded; the failures were 2,801. In the Intermediate Stage 19,093 papers were worked. The number of first class certificates was 2,756, second class 10,216 and failures 6,121. In the Elementary Stage, only one class of certificate is granted; of the 24,049 papers worked, 15,994 gained certificates and 8,055 failed to do so.

PROCEEDINGS OF THE SOCIETY.

HOWARD LECTURES.

AERO ENGINES.

By Alan E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E.

Lecture I.—*Delivered January* 17*th*, 1921.

Mechanical flight has been a problem of great attraction from very early times. Though most early writers and experimenters conceived the prime mover to be man himself, reasoning from an analogy to bird flight, the few even long ago arrived at the conclusion that some more powerful motor than human muscles was practically a necessity. Giovanni Borelli, in 1680, says: "It is impossible that men should be able to fly craftily by their own strength," and Sir George Cayley, 1809, whilst admitting that man "if he can be made to exert his whole strength advantageously upon a light surface similarly proportioned to his weight as that of the wing of a bird . . . . . would fly like a bird." However, he says, "To produce this effect (practical flying with considerable weight) it is only necessary to have a first mover which will generate more power in a given time, in proportion to its weight, than the animal system of muscles."

Though Sir George Cayley, judging by his qualification only, apparently did not think the prime mover to be a great difficulty it proved to be so in effect, for we successfully flew on gliders before we had developed the first mover to impel them.

In these early days Sir George Cayley saw that the only prime mover then available, the steam engine, was not the only agent, for he says, after dealing with possible developments of Watt's steam engine, "It may seem superfluous to inquire further relative to a first mover for aerial navigation, but lightness is of so much value in this instance that it is proper to notice the probability that exists of using the expansion of air by the sudden combustion of inflammable powders or flints with great advantage," instancing an early oil engine of William Chapman, of Newcastle.

The earliest internal combustion engine described in this country, however, appears to have been that of Robert Street, in 1794. This motor contained a cylinder heated at the bottom by a fire to evaporate spirits of turpentine below a motor piston. The motor piston was drawn up and air allowed to enter to mix with the vapour, which was then ignited driving the piston further upwards and forcing a pump piston up by means of a lever, the return stroke being performed by the weight of the motor piston. Sir George Cayley was evidently

aware of the advantages which might be obtained with this type of engine, although he apparently did not know of the proposal of Street, for he states, "Probably a much cheaper engine might be produced by a gas light apparatus and by firing the inflammable air generated with a due proportion of common air under a piston." The last sentence represents more or less exactly the aero engine we have to-day, carburetted air mixed with ordinary air fired electrically against a piston. However, the successful aero engine was to be long in coming, so long that the steam engine was still the only possible agent for experimenters who had arrived at the stage of completing their designs, up to the prime mover, until practically the present day.

In searching for possible means for producing motive power other than the steam engine, the early investigators considered a very great number of possible combustible materials for utilisation by the internal combustion method; both gaseous, liquid and solid materials were contemplated, but up to the present success has only been achieved by the use of gaseous and liquid fuels. The relative value of a few of the different substances that have been proposed for the purpose of producing power depends, of course, primarily on the quantity of heat evolved on combustion. The calorific values for a number of different materials are given in Table 1, the products of combustion being assumed to be carbon dioxide, sulphur dioxide and water in the state of vapour. The heat values are given in British thermal units per lb. of the material in each case.

TABLE I.

CALORIFIC VALUE OF DIFFERENT SUBSTANCES. BRITISH THERMAL UNITS PER POUND.

Hydrogen	34800
Marsh Gas	23500
Acetylene	21450
Amyl Alcohol	16100
Ethyl Alcohol	12900
Methyl Alcohol	9600
Benzol	17900
Crude Petroleum	19800
Petrol	19800–20100
Bituminous Coal	11000–14000
Anthracite	12600–13400
Coke	12600
Pine containing 12% of water	7950
Oak containing 12% of water	7150
75% Dynamite	2320
Gunpowder	1300
Explosives of Ammonium Nitrate Class containing 83% of Ammonium Nitrate ..	1470
Trinitro Toluol. (T.N.T.) ..	6498

From the above Table it will be seen that the fuels which are in practice used in internal combustion engines are some way down the scale as regards possible heat value per unit weight of fuel. The advantage on this basis of utilising a fuel with high hydrogen content will be evident from the Table. The practical difficulties to be expected are great; but as light weight is of such fundamental importance in flying the question of the production of a higher value fuel seems to merit consideration.

Explosive compounds such as are used in guns could be applied in cartridge form to the turbo engine, but the practical difficulty, the weight, since the oxygen for combustion is to a great extent to be carried with the compounds, renders their use prohibitive.

The use of steam in turbines, instead of internal combustion engines, is advocated on the score of greater reliability, but it must not be forgotten that this reliability with high efficiencies has only been obtained on land plants, where weight considerations could to a great extent be disregarded. The great disadvantage of generating heat outside the working fluid is, of course, that it involves the use of a boiler in addition to the motor itself, and, if high efficiencies are to be obtained, a superheater and an efficient condenser. The latter alone, on account of the necessity for expanding to very large volumes and for using air-cooling for condensation with the consequent large bulk and head resistance, would prevent any approach to the highest possible turbine efficiencies for flight purposes. On this account even the most recent developments of the steam turbine cannot compete with the modern aero engine as regards weight for power. As regards thermal efficiency, the steam turbine plant is still considerably behind the modern aero internal combustion engine plant. For low engine weight, moreover, it would be necessary to employ high speed impulse type turbines, and this again would involve the use of gearing; it is probable that a low weight steam turbine plant would only be obtained at the expense of considerable reduction in thermal effici-

ency. Hence it appears that the use of the steam turbine for aerial work is bound to be a limited one.

The first successful steam turbine was running about 1884, driving a dynamo and developing about 10 horse-power at a speed of 18,000 revolutions per minute.

A great step forward was made about 1890, and the first condensing steam turbine was produced in 1892, developing 200 horse-power, at a speed of 4,800 revolutions per minute, with a steam consumption of 16 pounds per indicated horse-power hour. This marked a great advance in steam turbine construction, and since that date there has been continuous improvement in efficiency, until at the present time it is considered by Sir Charles Parsons that overall brake thermal efficiencies approaching 28% are within reach of attainment in large plants of the order of 25,000 brake horse-power.

and the internal combustion engine for general purposes, the question of weight was not of primary importance; thus the weights were generally much in excess of those which we have become accustomed to in aerial work. In the aero engine the fullest advantage has been taken of the very extensive research which has been carried out with almost all possible materials of construction for the different parts of the engine.

The weight of the engines given in Table 2 varies from 150 lbs. to 500 lbs. per B.H.P. according to the different types.

Some indication of the weight of steam turbine plants as compared with internal combustion engines may be gathered from the fact that the total weight of turbines and shafting in the "Turbinia," built in 1896, was 4.09 lbs. per I.H.P. In this plant the turbines ran at the high speed of 2,300 r.p.m.

TABLE 2.

THERMAL EFFICIENCY TO HEAT IN FUEL.

Type of Engine.	Date.	Particulars of Engine.	Thermal Efficiency.	
			Indicated.	Brake.
Steam Engines	1884	Compound Reciprocating	10.8	9.7
	1892	First Condensing Steam Turbines	9.2	7.8
	1904	Condensing Steam Turbines	14.3	12.1
	1914	Condensing Steam Turbines	19.6	16.6
Gas Engines. Efficiency Calculated from Heat in Coal with assumed Efficiency of 85% for producer	1884	Crossley. 8.5″ x 14″	14.5	12.2
	1892	Crossley. 8.5″ x 18″	19.4	14.8
	1904	National. 14″ x 22″	29.9	25.4
	1908	Crossley. 11.5″ x 21″	31.4	27.2
Heavy Oil Engines	1890	Priestman. 8.5″ x 12″	12.2	10.5
	1894	Crossley. 7″ x 15″	17.5	15.6
	1903	Diesel. 15.75″ x 23.6″	39.7	32.6
	1910	Mirrlees-Diesel 12″ x 18.25″	43.4	31.6
	1920	Ruston High Compression	41.3	35.1

The use of the uniflow steam engine may possibly be considered as an alternative to the steam turbine.

The above table, number two, gives some average thermal efficiencies of internal combustion engines and steam turbines since 1884, and shews clearly the progress which has been made in this respect in both forms of producing motive power.

In the development of the steam turbine

In the stationary motive power plants noted, the materials used were practically only cast iron, wrought iron and steel, all of which were of low tensile value. At the present date the tensile values of steels used for aero engines are as high as 100 tons per square inch; the advantage of this is obvious. Aluminium alloys have also made enormous progress in recent years, having replaced iron and steel for

many parts used in aero engine construction.

The specific gravities of various materials are given in Table 3.

TABLE 3.

SPECIFIC GRAVITIES OF VARIOUS METALS.

Lead	11.0
Copper	8.9
Nickel	8.7
Bronze	8.7
Steel	7.8
Wrought Iron	7.7
Cast Iron	7.5
Manganese	7.4
Tin	7.0
Zinc	7.0
Chromium	6.8
Antimony	6.6
Aluminium (Commercial)	2.6
Magnesium	1.75

In this table only specific gravities of elements are given; in practice various alloys are employed and the specific gravity of any particular alloy will be readily obtained when the different percentages are known.

In the early attempts at producing a motor of sufficiently high power-weight ratio to lift a heavier-than-air machine from the ground, thermal efficiency was naturally regarded as of secondary importance, and it is of interest to note a few of the steam engines which were produced by the early inventors.

Langley produced a high pressure steam engine for a model aeroplane stated to give 1¼ horse-power with an engine weight of only 1.625 lbs., and a boiler weight of 5 lbs., so that the total weight of the power unit would be 6.625 lbs. or 4.4 lbs. per horse-power; but, as would be expected, no practical advance in power-propelled machines resulted from these experiments.

Maxim, in 1895, produced a steam plant employing a high pressure compound engine, Fig. 1, which had a high pressure cylinder 5 inches in diameter and a low pressure cylinder 8 inches in diameter, with a stroke of 12 inches. A tubular boiler was employed generating steam at a pressure of 320 lbs. per square inch, the boiler being heated from a petrol furnace. The total weight of the boiler, furnace and engine was 2,000 lbs.; the capacity of the plant was 350 horse power, so that the weight amounted to 5.7 lbs. per horse-power.

None of these early steam plants designed with a view to minimising weight per horse-power attained any practical success and the attempts are only of historical interest.

Before discussing the thermodynamic cycles which are used in successful aero engines at the present day and those which give promise of successful development for special engines, it will be of interest to note the different ones which were used in the early development of the internal combustion engine.

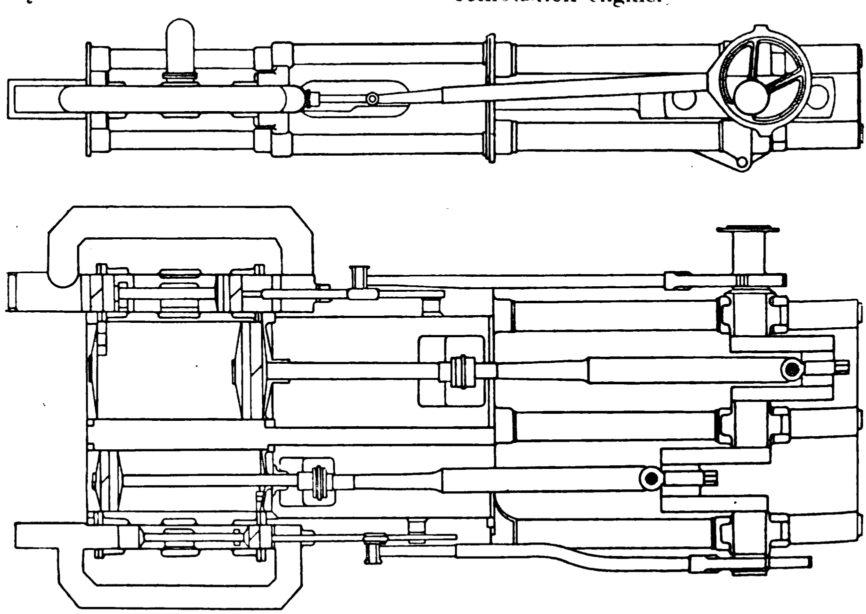


FIG. 1.

In Type 1, used by Lenoir, the combustible charge was ignited at atmospheric pressure with the piston in the centre, and expanded adiabatically to atmospheric pressure or a pressure slightly above.

In a variation of this type the heat is added at constant volume and adiabatic expansion is continued to the lowest temperature, the heat being rejected at constant temperature so that during the instroke of the piston the line traced on the diagram is isothermal.

In the above type there is no compression of the charge before ignition; the efficiency is very low, but engines working on these cycles did attain considerable commercial success.

In all the later engines the charge is compressed before ignition from atmospheric pressure to some higher pressure and ignition takes place at the higher pressure.

In Type 2 the charge is compressed adiabatically from atmospheric pressure to the maximum pressure. It is then ignited and heat added at constant pressure. Adiabatic expansion then takes place until atmospheric pressure is reached and the heat is rejected during the instroke of the piston at atmospheric pressure.

In a modification of this type the expansion is stopped before atmospheric pressure is reached, the heat being rejected at constant volume. A diagram of this is shewn at Figure 2. This type is the ideal cycle of the Brayton, Diesel and other constant pressure engines.

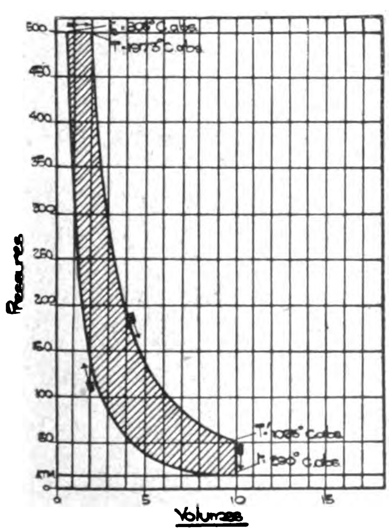


FIG. 2.

According to the third type the charge is compressed during the instroke of the piston, heat is added to the compressed charge at constant volume, and the charge is expanded adiabatically to the same volume as before compression. The heat is rejected at the constant maximum volume. This is the type of the Otto and other four-stroke cycle engines. The corresponding diagram is shown at Figure 3.

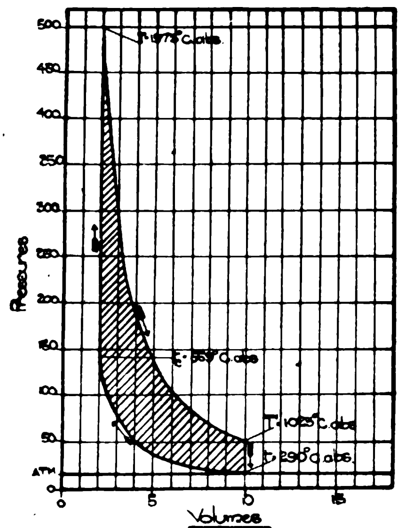


FIG. 3.

It is of interest to note that in the aero engine the ideal diagram at altitude is modified owing to the low atmospheric pressure and lower temperature. The effect of the lowering of the pressure at altitude and the lowering of the temperature are shewn separately and combined at Figure 4.

In diagram I, the inlet pressure and temperature are those existing at ground level; in diagram II. ground level pressure is taken with the average temperature at 20,000 feet; in diagram III. the pressure is the average pressure at 20,000 feet with ground level temperature and in diagram IV. the average pressure and temperature at 20,000 feet are taken.

According to a modification of Type 3, the expansion may be carried further than the original volume, to atmospheric pressure or some higher pressure. This cycle, expanding to a volume greater than the original volume and rejecting heat partly at a constant volume from a pressure greater than atmospheric pressure and partly

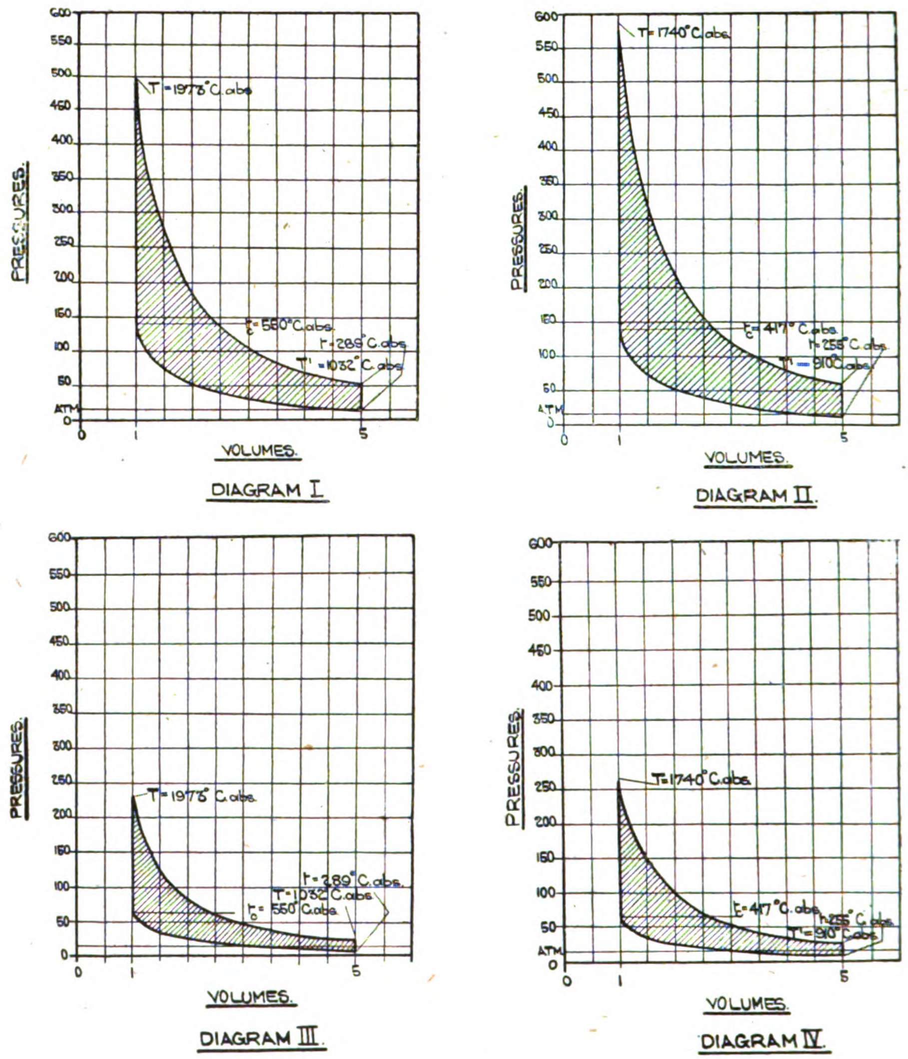
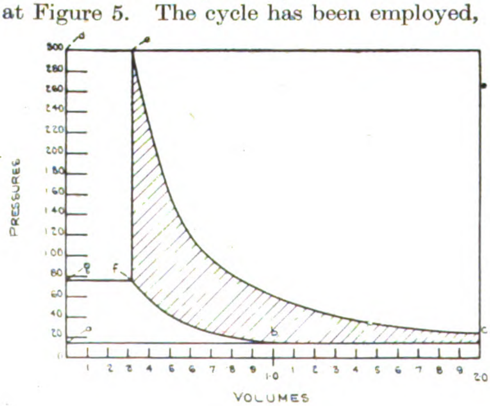


FIG. 4.

at constant atmospheric pressure, is shown at Figure 5. The cycle has been employed,



as will be shewn later, and may be of use in the future development of aero engines.

It may be remarked that there are three symmetrical thermodynamic cycles according to which a heat engine, in which the working fluid is compressed before heat addition takes place, can operate. In all of these, the ideal thermal efficiency will be the same if the ratio of compression is the same, that is, the ratio of the volume of the working fluid before compression to its volume after compression and before the addition of heat.

In these cycles the efficiency is $1-\left(\frac{1}{r}\right)^{\gamma-1}$ where $\left(\frac{1}{r}\right)$ is the compression ratio and γ

is the ratio of the specific heats of the working fluid.

The three symmetrical cycles are :—

I. The Carnot cycle, in which the four stages are :—

(1) Compression of the working fluid without the addition of heat from the initial volume, which may be taken at atmospheric pressure to the minimum volume. By this compression the temperature will have risen from the initial temperature T_0 to the maximum temperature T_c, this rise of temperature being caused by compression alone with a corresponding quantity of work done on the working fluid by the piston.

(2) Expansion at constant temperature with addition of heat. This is the stage in which the total energy of the working fluid is increased by the addition of heat from the source.

(3) Adiabatic expansion from the point at which the whole of the additional heat has been added to a volume many times greater than the initial volume. During this stage the working fluid neither gains nor loses heat.

(4) Compression from the maximum volume to the initial volume at constant temperature. During this period the heat is rejected from the working fluid and absorbed by the sink. The constant efficiency is determined by the ratio of the volume before adiabatic compression on the first stage to the volume at the end of this adiabatic compression, and this volume ratio is equal to the ratio of the volumes of adiabatic expansion.

II. The constant volume cycle. This is the well-known cycle of the ordinary Otto four-cycle engine. The working fluid is first compressed without addition of heat, then heat is added at constant volume, the working fluid is expanded from the minimum volume to the initial volume without gain or loss of heat, and heat is rejected at constant volume.

III. The constant pressure cycle. This cycle is the perfect cycle on which it was at one time commonly stated that the Diesel and like engines worked. It will be seen from the diagram, however, that for practical purposes the high efficiency of this cycle is unattainable owing to the very considerable cylinder volume required for a given maximum pressure and heat addition. The four stages are :—

(1) Compression without heat addition from the initial pressure and initial volume to the minimum volume and maximum pressure.

(2) Addition of heat at maximum pressure with increase of volume.

(3) Expansion without gain or loss of heat to the original pressure to a volume many times greater than the initial volume.

(4) Compression at constant minimum pressure to the initial volume.

Of these three cycles the constant temperature, or Carnot cycle, is impracticable owing to the enormous range of expansion and temperature and excessively small mean pressure, and the complete constant pressure cycle is impracticable owing to the very large expansion required. The complete constant volume cycle, on the other hand, gives quite a reasonable expansion and ratio of maximum to mean pressure.

In each of these three symmetrical cycles, the ratio of volume before adiabatic compression to volume at the end of adiabatic compression is equal to the ratio of the volume at the end of adiabatic expansion to the volume at the beginning of adiabatic expansion, and in this sense the cycles are symmetrical.

As is well-known in any heat engine, if T is the temperature of the source and T′ the temperature of the sink, the thermal efficiency E is

$$E = 1 - \frac{T'}{T}$$

Taking compression cycles, if T_0 is the initial temperature before adiabatic compression, T_c the temperature of compression, T the maximum temperature and T' the temperature at the end of adiabatic expansion.

In the Carnot cycle $T' = T_0$ and T is equal to T_c.

In the constant pressure cycle $\frac{T'}{T}$ is equal to $\frac{T_0}{T_c}$ since the two points on the diagram giving T', T; and T_0, T_c lie in each case on a horizontal pressure line.

In the constant volume cycle $\frac{T'}{T}$ is also

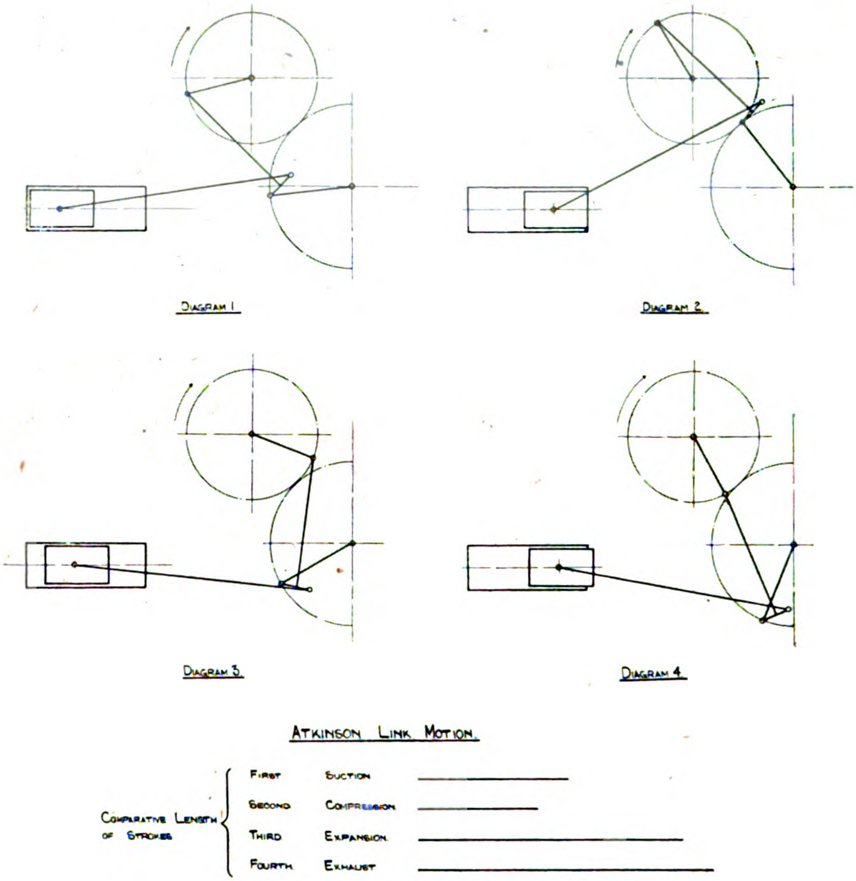


Diagram 1
Diagram 2
Diagram 3
Diagram 4
Atkinson Link Motion.
Comparative Length of Strokes
First Suction
Second Compression
Third Expansion
Fourth Exhaust

Fig. 6.

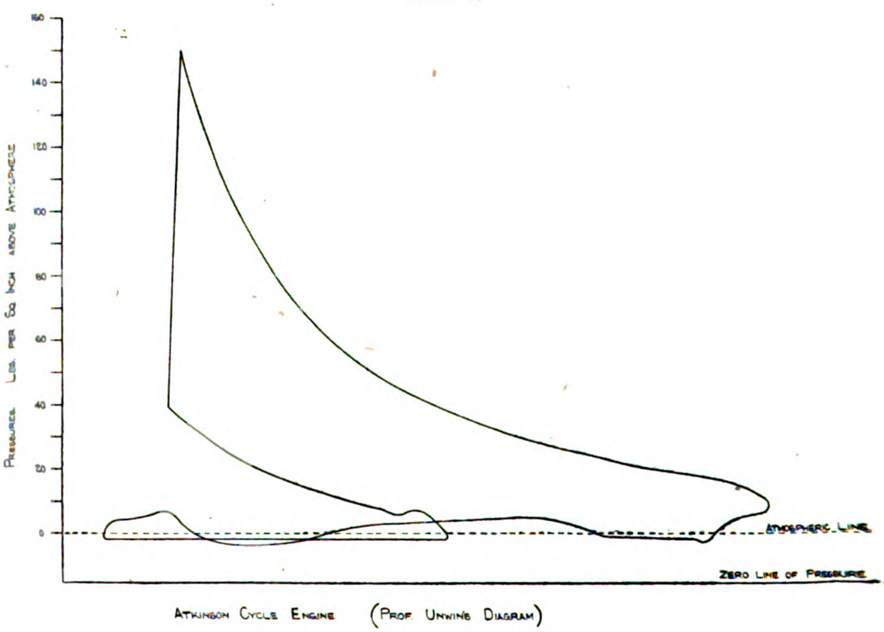

160
140
120
100
80
60
40
20
0
Pressures Lbs per Sq Inch above Atmosphere
Atmospheric Line
Zero Line of Pressure
Atkinson Cycle Engine (Prof. Unwin's Diagram)

Fig. 7.

T_0
= to — because T and T_c; and T' and
T_c
T_0 lie respectively on two vertical lines along which the volume is equal. Since the temperature of compression for a given initial temperature is dependent only on the compression ratio, it follows that the efficiency of the three cycles is the same for the same compression ratio.

Of the above cycles only the constant volume cycle, Type 3, expanding to initial volume, and the constant pressure cycle, Type 2, expanding also to initial volume, have been extensively developed. The third cycle illustrated, Type 2, expanding beyond initial volume, was used in the Atkinson cycle engine in 1886. An ingenious link motion was employed to obtain a variable stroke of the piston. The link motion is illustrated at Figure 6. An engine of this type was tested at the Trials organised by the Royal Society of Arts in 1888, and developed a brake horse-power of about 9.5 B.H.P. at a consumption of 22.6 cubic feet of gas per B.H.P. hour at 131 r.p.m., with a mean pressure of about 46 lbs. per square inch. The mechanical efficiency was 85 per cent. and brake thermal efficiency about 20 per cent. A diagram taken on the Atkinson engine is shown at Figure 7. This cycle is also used in the Humphrey pump.

It should be noted that in all engines working on the constant volume cycle the combustion is not instantaneous, and in many cases combustion continues considerably after the point of maximum pressure is reached. The effect of this is to produce a diagram in which part of the heat may be said to be added at constant volume and part at constant pressure. Attempts have been made by Sir Dugald Clerk and others to produce this condition by regulating the fuel supply, and it has been suggested that the cycle should be termed the dual combustion cycle. The control of combustion would, however, be so uncertain that in considering ideal cycles no very definite air standard cycle could, in the author's view, be evolved.

The Blackstone oil engine would appear to work on this cycle.

It may be noted that by keeping the inlet valve of an ordinary four-stroke cycle engine open during a portion of the compression stroke a diagram is produced which is similar to that obtained in the Atkinson cycle. This is of interest in view of certain recent proposals for limiting the power at ground level of an aero engine specially designed for the low atmospheric pressures at high altitudes.

The internal combustion engine had to go through a long practical development before it reached the stage at which it could be employed for flight purposes.

The first important stage in the development was the use by Otto of the Beau de Rochas cycle in the production of the first compression engines in 1880, and this type has been adopted in practically all aero engines of the present day.

The Otto engine utilised town gas as fuel. The mean pressure was low, only about 70 lbs. to the square inch, with an indicated thermal efficiency of 16 per cent. and brake efficiency about 13.9 per cent. The cylinder was 171.9mm. diameter by 340 mm. stroke and the engine ran at a speed of 157 r.p.m.

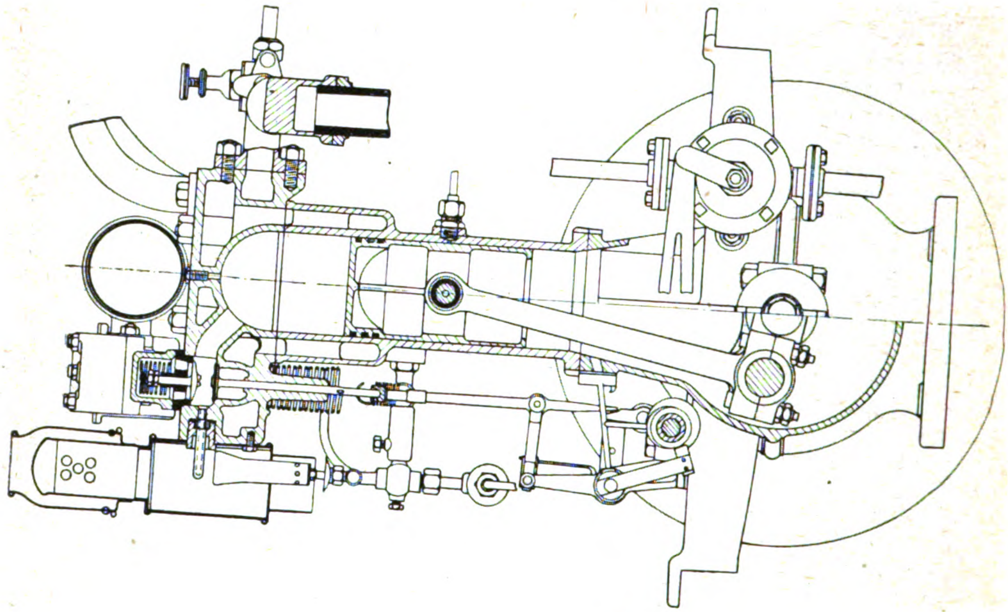
The success of the early Otto gas engines quickly led to the production of heavy oil engines working on the same cycle, but these, owing to their considerable weight, have not yet reached the stage at which they can be employed for aero motors.

At the early period also, engines working on the two stroke cycle were designed and built by Sir Dugald Clerk and engines of this type were constructed of large powers, chiefly on the Continent. The four-stroke cycle, however, was very much more extensively used and developed.

For light weight aero motors the two-stroke cycle deserves serious consideration as offering advantages, particularly in connection with direct fuel injection.

A very great advance was made by Gottlieb Daimler using petrol as fuel in engines of comparatively small size, and the work of Daimler led him to the first application of the Otto type of internal combustion engine to motor vehicles. A section of the Daimler engine as applied by Gottlieb Daimler to a motor carriage in 1896 is given at Figure 8. This engine of Daimler may be regarded as the prototype of the modern forms of car, motor boat and aero engines. Engines following this type were the first which were successfully used for flight.

At about the same time as the rapid development in the four-stroke cycle constant volume engine took place, engines were also developed working on the constant



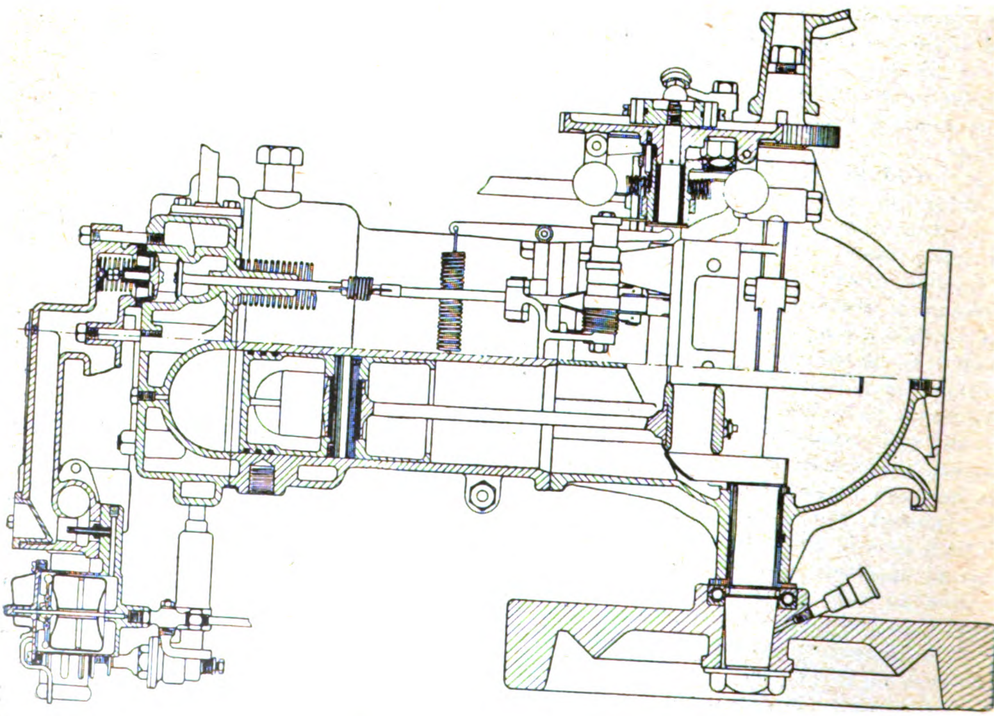


FIG. 8.

pressure cycle. The earliest example of these engines is the Brayton petroleum engine in which the charge of fuel or air was compressed in one cylinder and ignited as it passed into a second or motor cylinder. The constant pressure type has been extensively developed, and was very early proposed for motor vehicles in the U.S.A. The type is represented in modern practice wholly or in part by the Akroyd Stuart, Diesel and Semi-Diesel engines.

The weights of internal combustion engines depend on the compression pressure used, and for the same cycle the weight will have to be greater proportionately with the compression pressure, and cycles involving very high compression ratios or very long expansions and giving increased economy, also increase the weight of the engine; efforts to utilise a longer expansion by compounding the engine have not been successful owing to heavy heat loss in transfer to the low pressure cylinder. For aero engine use, particularly for heavier-than-air machines, weight of engine is of fundamental importance, and it appears that for this purpose the constant volume type of engine is to be preferred. For engines where weight is of less importance and high economy involving less weight of fuel to be carried is the governing factor, engines of the constant pressure type with self-igniting cycles may prove to be more suitable. Such engines may quite well turn out to be extremely suitable for airship work.

The first really successful engine used for flight was that of the Wright Brothers, used in their early flights about 1903. This engine was of the constant volume type with four vertical cylinders 4¼ inches diameter by 4 inches stroke, and developed 24 B.H.P. at a speed of 1,200 r.p.m. with a petrol consumption of .825 lbs. per B.H.P. hour, giving a brake thermal efficiency of about 15.5 per cent. The weight of the engine was 210 lbs. The separate cast steel cylinders had inlet valves of the automatic type, and exhaust valves operated by push rods. Thin aluminium water jackets were provided on the cylinder barrels. The weight per B.H.P. was over 7 lbs.

In France, successful flights were made using the Antoinette engine. This was a Vee type with eight cylinders, 4.35 inches bore by 4.15 inches stroke, giving 49 B.H.P. at 1,100 r.p.m., and weighing 265 lbs.; that is, about 5.4 lbs. per horse-power.

In both the Wright and the Antoinette engines the brake mean pressure was about 65 lbs. per square inch. The results obtained with these two motors may be said to have clearly demonstrated the suitability of the four-stroke cycle petrol engine to provide motive power for heavier-than-air machines.

A further engine development in France before 1909, and of historical interest, is the three cylinder radial air-cooled Anzani engine used by Blériot in the first Channel flight. This engine developed 25 B.H.P. at a speed of 1,400 r.p.m. The cylinders were of cast iron fitted with valves in a side pocket, the inlet valves being automatic and the exhaust valves operated by push rods. The cylinders were of 3.94 inches bore by 5.92 inches stroke, piston speed 1,380 feet per minute, brake mean effective pressure 65.5 lbs. per square inch, and petrol consumption 0.6 lbs. per B.H.P. hour, giving a thermal efficiency of 21.2 per cent. The weight of the engine was 140 lbs. or 5.6 lbs. per B.H.P.

An interesting engine for aviation was proposed by Messrs. Burlat in 1904, but did not attain any practical success. In this engine the cylinders and crankshaft rotate in the same direction, the crankshaft speed being twice that of the cylinders. A two-throw crankshaft was employed connected to the centres of two rigid connecting rods, each of which had a piston at each end, the pistons working in opposed cylinders. The crankshaft axis was situated at one half the radius from the centre of the trunnions on which the cylinders revolved, and the length of crank throw was also one half this radius. In the engine, as designed, the propeller was fitted to the crankshaft, but the mechanical arrangement suggests that a reduction of propeller speed relative to engine speed can be obtained without the use of gearing.

The most successful engine produced for flight in the early period of development was the Gnome engine designed by M. Seguin. This was the forerunner of the well-known radial air-cooled rotary type which is still very extensively used.

In this type the cylinders are arranged radially and rotate about the axis of a single throw crankshaft which is fixed, and through which the fuel and lubricating oil are fed; thus the pistons rotate about a fixed crank pin.

An odd number of cylinders are required in order to obtain working strokes at equal

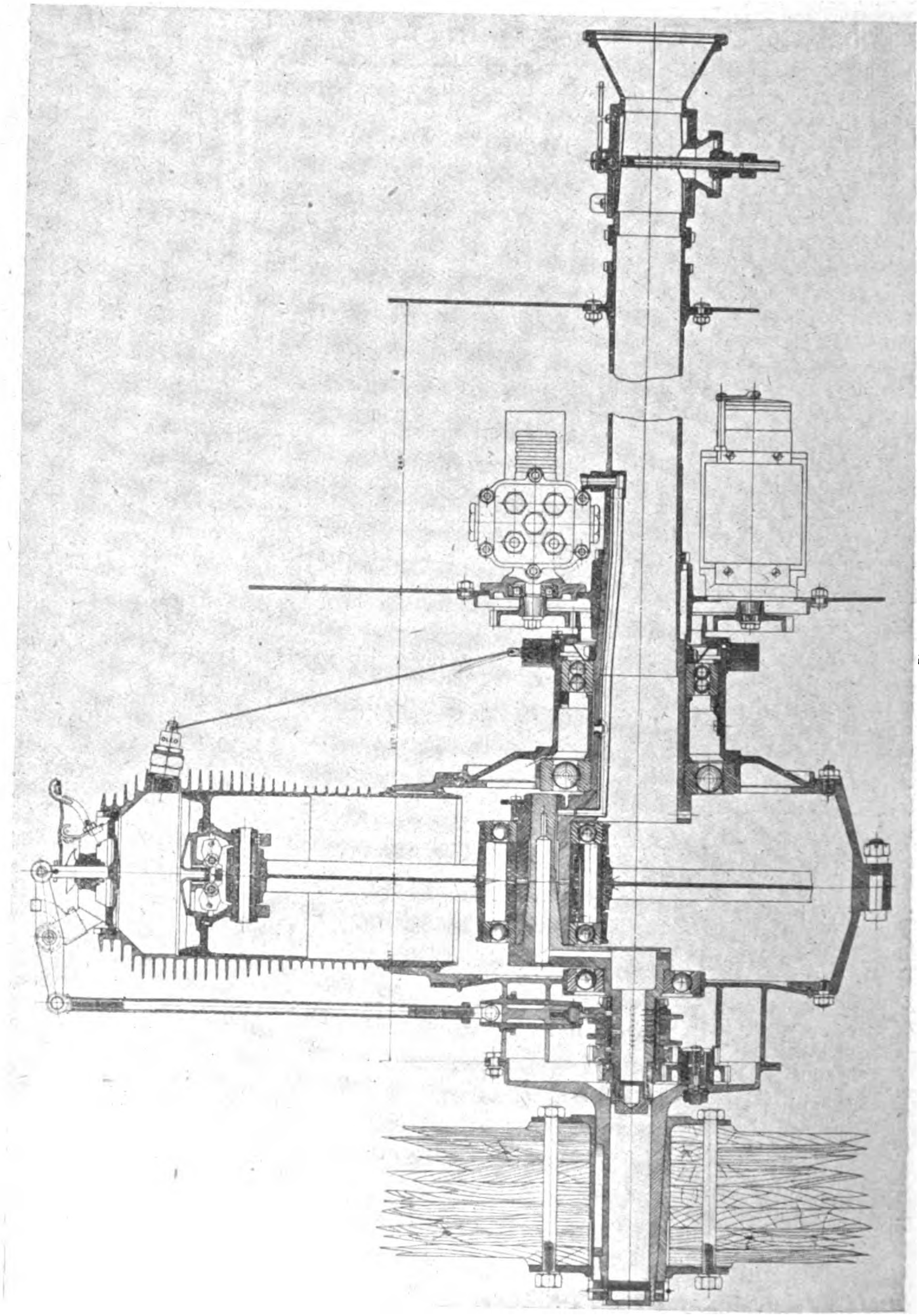


FIG. 9.

angular intervals during each revolution of the cylinders. In the earliest type, five cylinders were employed of 3.94″ bore and 3.94″ stroke; later, the well-known seven cylinder 80 H.P. type, Figure 9, was produced. These engines were much lighter than any other engine produced at this early date, and were very widely used.

The crankshaft is in two parts, fitted together at the crank pin, the long end being fixed in the engine bearer plates on the aeroplane. The crank case and cylinders rotate about the crankshaft on ball bearings, while the connecting rods are connected to a banjo-shaped big end formed on the master rod. The cylinders are machined from solid nickel chrome steel ingots, the thickness of the barrels being only 1.5 mm. The exhaust valves are situated in the cylinder heads and are actuated by push rods and rockers, while the inlet valves are automatic and are situated in the heads of the pistons.

Fuel and air are led to the engine through the hollow crankshaft from a jet carburettor and the mixture passes from the crank-case to the cylinder through the valves in the pistons.

Although the fuel and oil consumption was heavy, as compared with contemporary stationary engine practice, the very light weight per horse-power, coupled with accessibility and ease of dismounting, made the type easily the most successful aero motor at the date of its first production.

The following table No. 4 gives some particulars as regards the aero engines which were in existence about 1910.

Since 1909 aero engine development has been rapid, and a number of different mechanical types have been produced. The symbolic representation of the main types which have been employed is shown in the diagram, Figure 10.

Of Type I, the stationary vertical engine with cylinders in line, may be mentioned Beardmore, Green, Benz, Mercedes and Maybach, which were all successfully used and had shewn great reliability before the commencement of the War.

The Beardmore type was constructed for powers of 90 and 120 H.P. before the War, and was very largely used. The engines had six cylinders set slightly on the forward side of the crankshaft axis. Water-cooling was employed, copper water jackets being deposited electrolytically. The crank-case was in two parts, the lower half

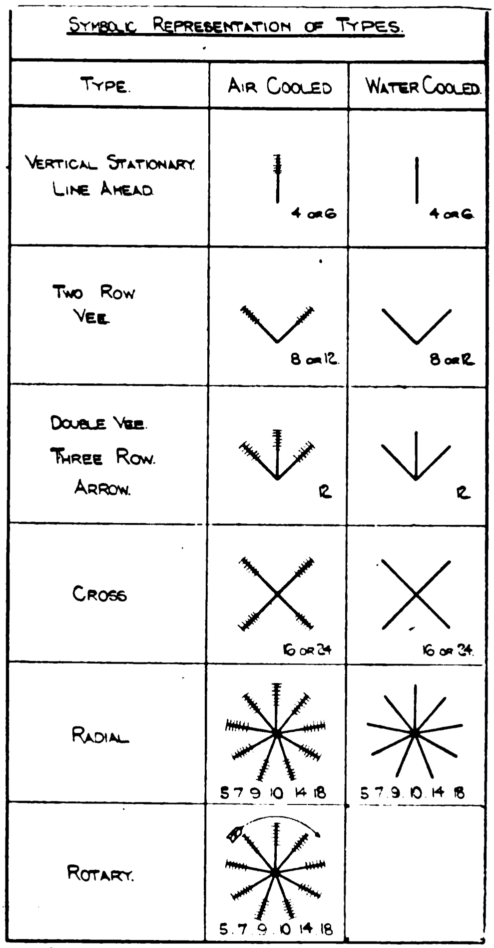


Fig. 10.

being removable without disturbing the crankshaft. The valves were of the overhead type operated by push rods and overhead rockers with special laminated springs. The dry weight of the 90 H.P. engine was 5.8 lbs. per B.H.P., and of the 120 H.P. engine 5.3 lbs. per B.H.P.

The Green engine was also a water-cooled engine with six vertical cylinders.

The Benz 100 H.P. engine obtained the first prize in the German official Aeroplane Trials in 1913, with the remarkably low fuel consumption of 0.47 lbs. per B.H.P. hour and the low weight of 4.22 lbs. per horse power complete with cooling system less fuel, oil and tanks. The tests at these trials were of a very searching description, and the performance must be regarded as a very excellent one at that date.

The Mercedes early engine developing 88.9 B.H.P., with a fuel consumption of

TABLE 4

Aero Engines Before 1910

Name of Engine	Wright	Antoinette	Anzani	Green	Wolseley	Pipe	Aster	Renault	Panhard	Gnome
Type of Engine	Vertical	Vee	Fan	Vertical	Vee	Vee	Vertical	Vertical	Vertical	Rotary
Cooling System	Water	Water	Air	Water	Water	Water	Water	Water	Water	Air
Number of Cylinders	4	8	3	4	8	8	4	4	4	7
Bore of Cylinders. Inches	4.25	4.35	3.94	5.52	3.74	3.94	5.12	4.33	7.28	4.35
Stroke of Piston. Inches	4.33	4.15	5.92	5.75	5.0	3.94	5.52	6.30	7.88	4.73
Brake Horse-power	24	49	25	60	54	55	51	38.5	112	45
Brake M.E.P. lbs. sq. in.	64.48	60.52	65.33	78.50	88.47	58.15	88.86	74.71	75.15	65.85
Revs. per Minute	1200	1100	1400	1100	1350	1950	1000	1100	900	1100
Piston Speed. Ft. per Min.	870	760	1380	1015	1125	1280	925	1155	1180	870
Dry Weight of Engine. Lbs	210	265	140	236	300	289	242	286	836	172
Weight per B.H.P. in Lbs.	8.7	5.4	5.6	3.94	5.6	5.3	4.75	7.4	7.5	3.8

.51 lbs. per B.H.P. hour and a weight of 4.4. lbs. per B.H.P., was a six-cylinder engine, and was awarded the second prize in these trials. This engine embodied many of the characteristic features of the well-known Mercedes construction, which will be dealt with more fully in describing the later engines.

The third prize at the German trials was obtained by the N.A.G. These were four cylinder engines.

Another interesting German engine is the Inverted Daimler. This obtained the fourth prize in the competition. It developed 65 brake horse power and the inverted construction gave the advantages of a better view for the pilot, lowered the centre of gravity of the engine, and improved the facilities for cooling. It is interesting that no difficulty was found with over-lubrication of the cylinders in spite of their inverted position.

The Maybach engine, as is well-known, was used in the early German Zeppelins, and a similar type was manufactured in this country by the Wolseley Company. An interesting engine of this type was the Argyll 120 h.p. engine, having rotating and reciprocating sleeve valves. This appears to be the only instance in which sleeve valves have been employed on aero engines. This engine competed in the War Office trials in 1914.

Of Type 2, the Vee Type, engines were constructed by the Wolseley Company, Sunbeam, Renault, de Dion, and others. The Wolseley engine was an eight-cylinder water-cooled engine, bore 3.75 inches and stroke 5 inches and developed 54 B.H.P. at a speed of 1,350 r.p.m.

Type 3, the three-row engine, is a development of the fan-shaped Anzani type, but was not extensively developed until a later period.

The same is the case with regard to Type 4, the cross engine having rows of 3, 4, 6 or more opposed pairs of cylinders placed at right angles.

With regard to Type 5, Radials, in development of the old Y type Anzani, two interesting engines at the War Office trials were the British Anzani, a radial engine having ten cylinders arranged in two groups of five and air-cooled; and the water-cooled nine-cylinder Salmson engine.

The air-cooled radial is of great interest in view of recent developments.

Type 6, the rotary, was, perhaps, the most successful of the earlier aero engines. The earlier Gnome engines and the Monosoupape Gnome nine-cylinder have always been pre-eminent and the Mono up to the present date has been very largely used latterly chiefly for training purposes. The engine is of bore 110 mm. and stroke 150 mm., and was by far the lightest engine at the British trials, the weight being about 2.7 lbs. per B.H.P. The consumption, however, of 0.7 lbs. per B.H.P. hour is high. The consumption of oil in this engine is also high.

The early Le Rhone engines were also produced about this time. The distinctive features of this type are the cylinder construction with a cast iron liner, connecting rod assembly, and the valve operation. These engines have been very successful and have shown considerable reliability.

An interesting type of engine manufactured in 1914 is the swash-plate type, an example being built by the Statax Engine Company.

In this type five cylinders are arranged parallel with the axis of rotation around a fixed hollow shaft and are held between two casings which rotate with them. The connecting rods are connected to the pistons by universal joints and their big ends are coupled to a ring mounted on ball and thrust bearings on an inclined swash-plate fixed to the shaft. The ring is constrained to rotate with the cylinders and casing by guides on the casing surrounding the swash-plate and thus any point on it rotates about the shaft axis and also oscillates in a rotating plane passing through the shaft axis. The cylinders are cooled by aluminium plates through which they are threaded. The inlet valves are operated directly by cams rotating concentrically with the shaft and the exhaust valves indirectly through push rods and tappets. This engine was claimed to develop 44 B.H.P. with a petrol consumption of 0.53 lbs. per h.p. hour and to weigh 176 lbs. or 4 lbs. per horsepower.

The leading particulars of aero engines in 1914 are given in Tables 5 and 6.

TABLE 5.

PARTICULARS OF LEADING ENGINES IN 1914. TEST FIGURES.

BRITISH WAR OFFICE TRIALS, 1914.

Make of Engine		Argyll	British Anzani	Beardmore Austro-Daimler		Dudbridge Salmson Canton-Unne			British Gnome Monosoupape		Green		Sunbeam	Wolseley. F2	Wolseley. Renlt.
Type		Vertl.	Radl.	Vertl.	Vertl.	Radl.	Radl.	Radl.	Roty.	Roty.	Vertl.	Vertl.	Vee	Vee	Vee
Number of Cylinders	No.	6	10	6	6	7	9	14	9	9	6	6	8	8	12
Bore of Cylinders	Ins.	4.92	4.53	4.72	5.12	4.72	4.72	4.72	4.33	4.13	5.51	5.51	3.54	5.00	3.78
Stroke of Pistons	Ins.	6.89	6.10	5.51	6.89	5.51	5.51	5.51	5.90	5.90	5.98	5.98	5.90	7.00	5.51
Brake Horse-Power	B.H.P.	116.6	100.2	95.5	129.0	89.0	124.0	185.0	99.2	104.2	101.7	103.5	130.9	139.6	113.5
Brake Mean Pressure	lbs sq"	48.95	36.39	50.99	47.12	40.89	44.25	41.45	42.71	48.00	37.72	38.52	54.37	39.44	33.64
Revs. per Minute	R.P.M.	1200	1110	1279	1275	1275	1276	1307	1206	1205	1246	1242	2046	1238	1800
Piston Speed	Ft.Mn.	1378	1129	1175	1464	1171	1172	1200	1187	1186	1243	1239	2014	1445	1654
Fuel per B.H.P. Hour	Lb.	0.57	0.95	0.69	0.54	0.58	0.55	0.61	0.69	0.72	0.67	0.63	0.53	0.58	0.66
Weight of Engine complete with Cooling System	Lbs.	600.0	464.0	437.1	583.8	432.9	545.6	780.2	275.0	275.0	506.1	507.3	565.1	810.7	478.8
Weight per B.H.P.	Lbs.	5.15	4.64	4.68	4.52	4.86	4.40	4.22	2.77	2.64	4.97	4.90	4.32	5.81	4.22
Weight of Power Plant with Fuel, Oil and Tanks for 4 hrs. ..	Lbs.	919.2	958.7	738.1	904.6	671.9	871.5	1303.9	655.4	716.0	835.2	818.2	896.1	1190.6	863.2
Weight of Power Plant, etc., per B.H.P.	Lbs.	7.9	9.5	7.7	6.96	7.55	7.20	6.95	6.60	6.86	8.22	7.91	6.84	8.54	7.60

TABLE 6.

PARTICULARS OF LEADING ENGINES IN 1914. TEST FIGURES.

GERMAN AEROPLANE ENGINE TRIALS, 1913.

Make of Engine		Benz.		Mercedes—Daimler				Argus					N.A.G.		Mu-lag.	Schroter	Bayerischen	Gyro
Type		Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Vertl.	Roty.	Roty.
Number of Cylinders	No.	4	6	4	4	4	6	4	4	4	4	6	4	4	6	6	7	7
Bore of Cylinders	Ins.	5.12	4.13	4.72	5.51	4.72	4.72	4.33	4.72	5.51	4.92	4.92	5.31	4.72	4.33	4.88	4.33	4.29
Stroke of Pistons	Ins.	7.09	5.51	5.51	5.90	5.51	5.51	5.51	5.51	5.51	5.12	5.12	6.30	4.72	6.69	6.30	4.72	4.76
Brake Horse-Power	B.H.P.	101.2	88.9	71.3	99.1	70.4	103.0	60.8	66.3	96.6	71.0	102.0	95.6	95.8	101.7	88.7	37.4	38.7
Brake Mean Pressure	Lbs sq″	107.0	114.2	103.5	102.0	107.5	107.0	104.8	98.0	106.4	107.5	101.1	101.0	95.0	101.1	79.2	66.6	77.0
Revs. per Minute	R.P.M.	1288	1387	1412	1373	1343	1315	1369	1391	1368	1342	1370	1344	1408	1346	1252	1031	954
Piston Speed	Ft. Min.	1523	1274	1297	1350	1233	1207	1282	1278	1256	1145	1169	1109	1400	1557	1314	812	757
Fuel per B.H.P. Hour	Lb.	0.47	0.51	0.50	0.49	0.50	0.53	0.50	0.50	0.53	0.59	0.59	0.52	0.49	0.53	0.63	0.86	0.77
Weight of Engine Complete with Cooling System	Lbs.	425	390	352	490	379	541	337	382	427	357	536	279	476	588	468	177	186
Weight per B.H.P.	Lbs.	4.20	4.37	4.91	4.91	5.36	5.23	5.51	5.72	4.40	5.00	5.22	4.96	4.98	5.76	5.27	4.72	4.80
Weight of Power Plant with Fuel, Oil and Tanks for 4 hrs. ..	Lbs.	657	605	525	719	545	799	502	546	692	566	829	409	696	834	705	340	351
Weight of Power Plant per B.H.P.	Lbs.	4.48	6.81	7.37	7.25	7.74	8.21	8.26	8.22	7.16	7.98	8.12	7.33	7.28	8.21	7.94	9.10	9.07

CORRESPONDENCE.

TIDAL POWER.

With regard to the proposal of Mr. Broadbent (*Journal*, August 26th, p. 685), there is no reason why power should not be generated in the manner he suggests. It is purely a matter of cost, but no one so far has been able to develop power from the tides at a price that would pay.

The reason why power generated from the *flow* of the tides is more likely to be a success than the system suggested by Mr. Broadbent is due to the fact that a higher efficiency can be obtained from turbines than from any known device for "the compressing and releasing of steel plates."

I would suggest that Mr. Broadbent search the records at the Patent Office to ascertain what has already been done on the lines he refers to. He would no doubt gain some very useful information thereby.

GEORGE C. BUCHANAN.

With reference to Mr. Broadbent's letter, permit me to inquire whether it would not be possible to secure a valuable amount of energy from the sea direct by making an excavation in coastland (geologically suitable) deeper than the lowest tide level, and then boring to obtain the required flow of water—such to be controlled and used—as in the case of (generated) wave power or tidal action.

By the way, what an apparent opportunity for an experiment of this nature exists in the already formed approach to the Channel Tunnel, if available.

My only fear is that the foregoing is too chimerical to deserve serious consideration.

GEO. FUTVOYE FRANCIS.

GENERAL NOTES

THOMAS NEWCOMEN.—Some two hundred years after his death, a memorial of Thomas Newcomen, inventor of the atmospheric steam-engine, has recently been erected at his birthplace, Dartmouth. Consisting of a massive block of Dartmoor granite, the monument is ornamented by a brass plate engraving of the celebrated Newcomen engine, and also bears the following inscription:—"This memorial was erected to the memory of Thomas Newcomen, inventor of the atmospheric steam-engine. Born in Dartmouth A.D. 1663. Died A.D. 1729. The first to conceive the idea of working a piston by steam." Newcomen became the partner of the ingenious "trench-master," Thomas Savery, whose numerous inventions included "a contrivance for rowing ships in a calm by means of two paddle wheels." Savery had taken out a patent for raising water from mines, and Newcomen so improved the machine that it furnished the model for pumping engines for three quarters of a century. Newcomen belonged to the ancient family of that name in Lincolnshire, who originally came from Brittany.

INSTITUTION OF MINING ENGINEERS.—The thirty-second Annual Meeting of the Institution of Mining Engineers will be held at Stoke-on-Trent, on September 14th, 15th and 16th, when the following papers will be submitted: "The Adsorption or Solubility of Methane and other Gases in Coal, Charcoal, and other Substances," by J. Ivon Graham, M.A., M.Sc.; "Suggestions for the Standardization of Geological Sections of Strata proved in Boreholes, Shafts, etc." by Harry Roscoe, O.B.E.; "Coal-mining by Steam Shovel in Alberta, Canada," by George Sheppard. Other papers which have appeared in the *Transactions* of the Institution, will also be open for discussion. The programme includes numerous excursions arranged by the Council of the North Staffordshire Institute of Mining Engineers, and a reception in the Town Hall, by invitation of the North Staffordshire Colliery Owners' Association.

TECHNICAL EDUCATION.—The Calendar of the Technical College, Bradford, for the Session 1921-22, gives details of the full-time (day) and part-time (mainly evening) courses in the departments of Textile Industries, Chemistry, Dyeing, Mechanical, Civil and Electrical Engineering and Biology of the College. The courses have been specially designed to meet the needs of students wishing to receive a technological training which will enable them to occupy higher positions in industry. The part-time courses form a large and important portion of the work of the College. In addition to the organised courses, special facilities are provided for students who may wish to undertake advanced study. The equipment of the College is extensive.

INDUSTRIAL PRODUCTION IN ITALY.—The Italian Confederation of Industry, according to the United States Commercial Attaché at Rome, is conducting a study of the production in the principal industries during the past year, as compared with that before the War. The preliminary results of this study show that in the metallurgical industry production is still greater than during the pre-war period, although there has been a marked decline from that during the war period. In the cotton industry production has decreased 2 per cent. as compared with pre-war years, and in the cement industry the decrease of production has reached 20 per cent. A 40 to 45 per cent. decrease is noted in the production of macaroni and similar products, and a 60 per cent. increase in that of chocolates, confectionery and biscuits. The production of shoes is reported to be steadily increasing.

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All communications for the Society should be addressed to the Secretary, John Street Adelphi W.C. (2)

NOTICES.

CANTOR LECTURES.

The Cantor Lectures on "Micro-Organisms and some of their Industrial Uses," by A. Chaston Chapman, F.I.C., F.R.S., have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been published separately, and are still on sale, can also be obtained on application.

CASES FOR JOURNALS.

Cases for keeping the current numbers of the *Journal* may be obtained post free, for 7s. 6d. each, on application to the Secretary. They are in red buckram, and will hold the issues for a complete year.

PROCEEDINGS OF THE SOCIETY.

HOWARD LECTURES.

AERO ENGINES.

By Alan E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E.

Lecture II.—*Delivered January 24th*, 1921.

When war was declared, among the engines of which immediate use was made, were the following:—

British—R.A.F., Beardmore, Gnome, Le Rhone, Renault, Curtiss, Green.

French—Gnome, Le Rhone, Renault, Anzani, Canton Unné.

German—Mercédès, Benz, and Argus, German Gnome, Oberursel; and for airship purposes the Maybach.

The average B.H.P. of the engines available at that date was about 100; the average B.M.E.P. was 71lbs./sq. in.; with a piston speed of 1280 ft./min., and a weight per horse power of 7.7lbs.

Of these engines, the Beardmore, Green, Mercédès, Benz, Argus and Maybach were of type I, that is, vertical cylinders in line; the R.A.F. and Renault were air-cooled, and the Curtiss water-cooled Vee type stationary engines; the Gnome and Le Rhone were rotary engines; the Anzani an air-cooled radial, and the Canton Unné, a water-cooled radial. It is seen that while the British had very few engines available, they immediately adopted certain existing French types, some of which were subsequently built in large quantities in Great Britain.

Of the French engines available during the early period of the war, the rotary type was perhaps the most used throughout, though the development, except in power, was not striking. The Vee type was largely used, and was very successfully developed as a water-cooled engine by various manufacturers, notably the Hispano type, designed by M. Birkigt. The essential characteristics of this engine are the high rotational speed and the simple valve gear; this type was produced in very large quantities in England, France, America, Spain and Italy. The Renault 12-cylinder water-cooled was another engine of the same type.

The Germans adopted for the very large bulk of their work, a single type on which there was available a large amount of data and experience built up in connection with racing engines for motor cars, boats and other purposes. They consistently kept to this type throughout the whole period of the war, except in the case of a few rotary engines, which are copies of designs got out originally by the French. At a late stage they were also attempting to

bring the high speed 8 and 12 cylinder Vee type into production. For example, the Benz Company were building these engines following the Hispano design with gearing of the Rolls Royce type.

The characteristic of the German engines used in the war is the attempt to obtain high fuel economy and reliability with less consideration of the feature of light weight per horse power than had been given by the Allies.

Many different types as to which little experience was available, were tried by the Allies throughout the war, and in order to get lighter weight, higher stressing was allowed than in German practice, with perhaps some sacrifice of reliability at the outset. Many types were but partially developed and were subjected to somewhat severe criticism before the development had been carried far enough for definite results to be obtained to allow the type to become standardised.

It may be stated that in Germany only the stationary vertical type of engine was seriously developed, and in France, only the Vee water-cooled type, both being developments of standard motor car engine practice.

In Great Britain development took place in several types, mainly the straight six as the B.H.P. Puma; the Rolls Royce Vee, and the air-cooled rotary. Large quantities of each of these types were produced.

The general course adopted with all types during the war was to increase the power by using higher compression and higher speed, overcoming the mechanical difficulties arising from these changes as and when they arose. Thus the Rolls Royce Eagle, which was originally rated at 255 H.P., was ultimately boosted up to 375 H.P. Similar procedure was adopted in Germany, but on more conservative lines.

This boosting up of the various types of engines was accompanied by considerable improvement in the materials employed in construction; for example the strength of steel used was increased from 40 tons to values of the order of 100 tons and very great advance was made in the quality of aluminium alloys enabling this material to displace iron and steel with consequent advantages as regards heat dissipation and saving in weight.

The most important original developments of the purely aero engine since 1914 have taken place in this country because we experimented with nearly all types. Progress was made particularly in the development of various air-cooled types. The Germans kept throughout to the water-cooled engines; the British used both air and water-cooling in different types from the beginning; first air with the R.A.F. engine, then water; though the air-cooled engine with its manifestly considerable advantages for military purposes, was, after being closely investigated as a scientific problem, perhaps more favoured as a type at the close of the war.

The Anzani, one of the very earliest of the fixed radial engines, was used at the beginning of the war, but this type was not developed to any great extent until 1918, and even then the results obtained hardly came up to expectations.

Again, the rotary engine, built in very large quantities throughout the whole period of the war, showed little real advance as regards design, although the power was considerably increased; such points, for example, as effective cooling of the following side of the cylinder being very incompletely explored; while the design of the cylinder head was always deficient in the provision of adequate heat-dissipating surface. The backward state of development of these types may perhaps be explained by the fact that the majority of aero engine manufacturers had gained their experience in car engine practice and would naturally select for development the type of engine with which they were best acquainted, or a close variation of this type, rather than select a new and different type, such, for example, as the air-cooled radial.

It will be interesting to follow the development of these air-cooled radial and rotary types when the demand for an aero motor of a weight per horse power not attainable with other designs is brought to the serious attention of our best technical men.

In order to study the progress in the different types through the war period, the engines may be grouped under certain standard types.

Six different types are diagrammatically represented in figure 10 (*Journal*, Vol. LXIX, p. 701). It is of interest to describe some of the best known engines of each of these types.

Taking first the vertical or I. type, Table 7 shows the particulars of the many German engines, and Table 8 the few British engines of this type produced during the war.

At the beginning this type was represented

TABLE 7.

GERMAN VERTICAL WATER COOLED ENGINES.

Make of Engine.		Mercédès	Argus	Benz	Mercédès	Mercédès	Argus (Opel)	Mercédès	Austro Daimler	Benz	Bayern	Mercédès	Mercédès	Basse Selve	Maybach
Number of Cylinders	No.	6	6	6	6	6	6	6	6	6	6	8	6	6	6
Bore of Cylinders	Ins.	4.72	5.12	5.12	5.51	5.51	5.71	5.51	5.31	5.71	5.90	5.51	6.30	6.10	6.50
Stroke of Pistons	Ins.	5.51	5.51	7.09	6.30	6.30	6.30	6.30	6.89	7.48	7.09	6.30	7.09	7.87	7.09
Total Swept Volume of Engine	Cu.Ins	579.5	681.0	876.3	901.2	901.2	967.4	901.2	916.8	1149.0	1164.6	1202.2	1326.0	1381.2	1412.0
Compression Ratio	R.	4.6	4.65	4.5	4.5	4.64	4.75	5.73	5.02	4.95	6.42	4.73	4.94	4.34	5.95
Brake Horse Power	Nml.	102.0	121.5	160.0	162.5	174.0	180.0	204.0	200.0	230.0	234.0	248.0	252.0	*269.0	294.0
Revolutions per minute ..	Nml.	1300	1300	1400	1400	1400	1400	1600	1400	1400	1400	1400	1400	1400	1400
Piston Speed in Feet per min.	Ft.Mn.	1195	1195	1655	1470	1470	1470	1680	1607	1745	1655	1470	1655	1837	1655
Brake Mean Pressure	lbs sq″	107.1	108.7	103.0	102.0	109.1	105.0	112.0	123.3	113.2	113.5	116.6	107.5	*110.0	117.7
Fuel per B.H.P. Hour	Lbs.	0.522	0.510	0.520	0.522	0.494	0.594	—	0.499	0.585	0.420	0.524	0.543	—	0.473
Oil per B.H.P. Hour	Lbs.	0.035	0.035	0.31	0.035	0.047	0.018	0.032	0.039	0.025	0.41	0.047	0.036	—	0.041
Brake Thermal Efficiency (18600 B.T.U. per lb.) ..	%	26.20	26.85	26.32	26.20	27.70	23.00	—	27.40	23.40	32.75	26.10	25.20	—	28.90
Weight of Engine complete with Cooling System	Lbs.	511.3	599.0	710.0	738.6	773.1	885.0	797.7	858.5	1012.8	795.5	1061.2	1126.0	1060.0	1102.0
Weight per B.H.P.	Lbs.	5.01	4.93	4.44	4.55	4.44	4.92	3.91	4.29	4.40	3.40	4.28	4.47	3.94	3.75

NOTE.—Figures marked with an asterisk are based on estimated horse-power. — Engine was damaged so that tests could not be made.

TABLE 8.

Vertical Water-Cooled Engines.

Make of Engine.		Beard-more.	Beard-more.	Gallo-way. B.H.P.	Siddeley Puma	F.I.A.T. A.12bis
Rated Horse-Power	H.P.	120	160	230	240	300
Number of Cylinders	No.	6	6	6	6	6
Bore of Cylinders	Ins.	5.12	5.59	5.71	5.71	6.30
Stroke of Pistons	Ins.	6.89	6.89	7.48	7.48	7.09
Total Swept Volume of Engine ..	Cu. Ins.	850.4	1015	1149	1149	1325
Compression Ratio	R.	4.85	4.56	4.96	5.00	4.75
Brake Horse Power	B.H.P.	133	178	236	240	317
Revolutions per Minute	R.P.M.	1200	1350	1400	1400	1600
Piston Speed in Feet per Minute ..	Ft./Mn.	1378	1435	1746	1746	1890
Brake Mean Pressure	B.M.E.P.	111.0	103.0	116.0	118.1	118.5
Fuel per B.H.P. Hour	Lbs.	0.530	0.520	0.520	0.500	0.524
Oil per B.H.P. Hour	Lbs.	0.030	0.032	0.030	0.062	0.031
Brake Thermal Efficiency. (18600 B.T.U.S. per lb.)	%	25.8	26.3	26.3	27.4	26.1
Weight of Engine complete with Cooling System	Lbs.	624	713	843	781	1065
Weight per B.H.P.	Lbs.	4.70	4.00	3.57	3.25	3.36

Note.—A special high compression Puma Engine has developed 300 B.H.P. at 1650 r.p.m. with a B.M.E.P. of 130lbs. per square inch.

in Great Britain by the 120 H.P. Beardmore and in Germany by the 100 H.P. Mercédès, the 120 H.P. Argus, and engines of 160 H.P. manufactured by the Mercédès and Benz Companies.

The 120 H.P. Beardmore was early followed by a more powerful type developing 160 B.H.P., and the latter engine was used with great success and to a very large extent during the war.

The 160 H.P. engine has six separate cylinders in line with electrolytically deposited copper water jackets. The crankshaft is placed slightly in advance of the central plane of the cylinders, and the lower half of the crankcase is removable without disturbing the crankshaft bearing caps. The construction of the crankcase in this respect differs essentially from that very largely adopted in the German engines of this type. The cylinders are of cast iron with steel flanges screwed on to the base, and are separately bolted to the crankcase. The valves are of the overhead type operated by push rods and overhead rockers, and are held to their seats by pivoted leaf springs, each end of a spring controlling an inlet and exhaust valve respectively. The inlet valve and cage can be removed by merely unscrewing the inlet bend.

In the earlier German engines, the Mercédès, Argus and Benz, the crankshaft journal bearing caps are cast in one with the lower half of the crankcase. By this means considerable stiffness is given to the crankcase, and to the engine as a whole, and the construction is characteristic of nearly all the German engines It is a useful feature in engines for aeroplanes in which there is no rigid bed provided for the engine.

The best known of the earlier engines mentioned are the 160 Mercédès and the 160 Benz, figures 11 and 12. As these engines are typical of two main German types it will be interesting to compare them. Both adopt the typical German crankcase construction referred to above.

In the Mercédès type, overhead valves are employed, actuated by an overhead camshaft situated over the tops of the cylinders, and operating the valves through rocker levers ; a construction which, applied to the Vee type, is also found in the Rolls Royce and Liberty Engines.

In the Benz construction, the camshaft is housed in the upper half of the crankcase, and the valves are actuated by push rods and rocker levers.

The Maybach engine which was largely used in airships from the very beginning

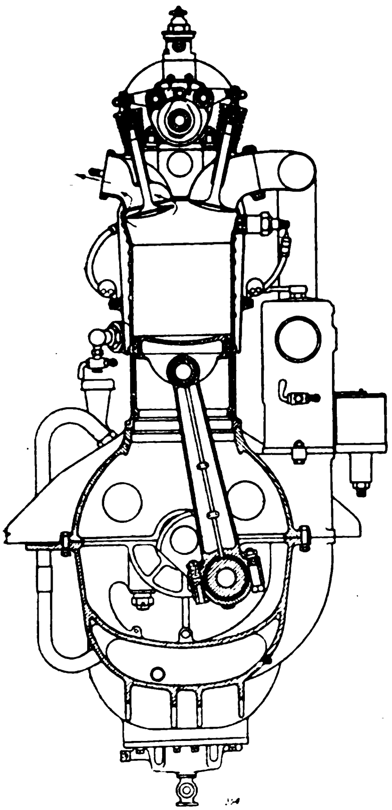

Fig. 11.

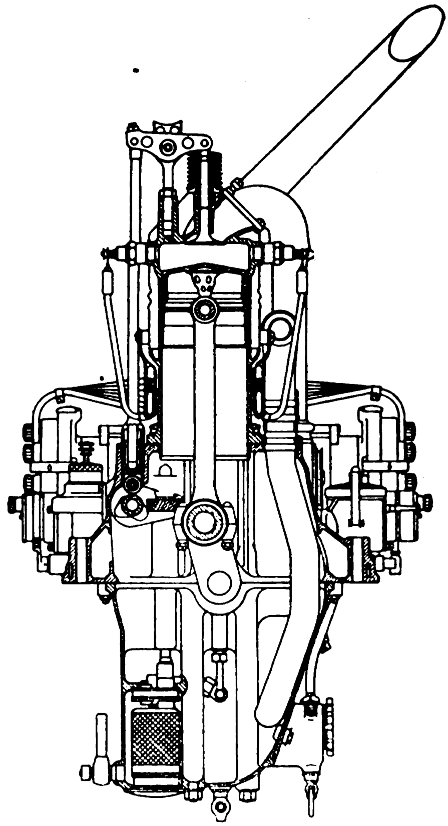

Fig. 12.

of the war employed the long push-rod type of valve gear. It was always particularly well-made and the size was increased from under 200 H.P. to 300 H.P.; the latter size was also constructed as an areoplane engine.

In the Argus construction, the valve gear is of the Benz type. The later engines, with the exception of the Maybach, all follow either the Mercédès or the Benz general design. This variation of the valve gear is the main difference in German types.

Practically the whole of the German aero engine development during the war was in this type of engine, and the particulars of the various engines which came into useful production are given in Table 7. It will be seen that increasing power requirements during the war were met by the fairly obvious modifications of increasing the number of cylinders in line, increasing the cylinder diameter, and increasing the compression ratio, and engines of increased power were from time to time produced by the Mercédès and Benz Companies.

Another engine of this type was the Bayern, which is of interest on account of its very high compression ratio, 6.42 to 1, and very low fuel consumption, the fuel used being a mixture of benzol and petrol.

The development of the stationary vertical engine in Great Britain resulted in the production of engines of about the same power as the German engine, but of a lower weight per horse power. The leading particulars of the chief engines of this type produced are given in Table 8. From this table it will be seen that the B.H.P. developed into the Puma, which was in production in its latest state of development at the time of the Armistice, and gave 240 B.H.P. at 1400 r.p.m. with a B.M.E.P. of 118lbs. per square inch, and a compression ratio of 5 to 1. The weight was only 3.25lbs. per B.H.P. as compared with the average weight of the larger German engines, namely 4.05lbs. per B.H.P. An engine of the Puma type with compression ratio raised to 5.4 developed on test 308 B.H.P. at 1650 r.p.m., with a consumption of 0.497lbs. of petrol per B.H.P. hour. The weight was 2.51lbs.

per B.H.P. This high compression engine did not, however, come into production.

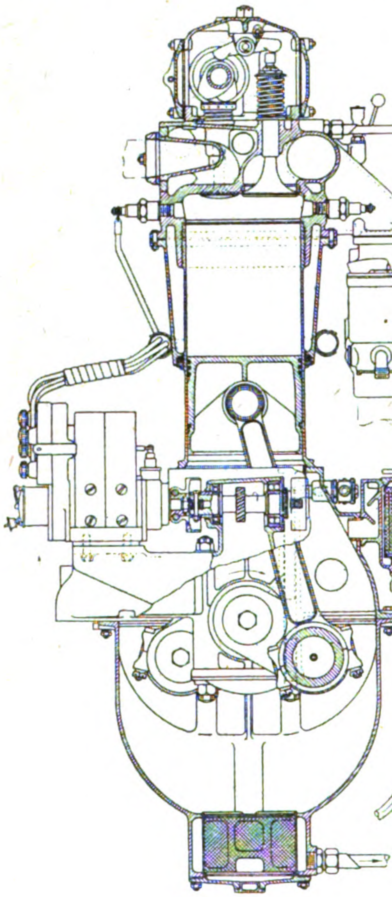

FIG. 13.

In the Puma engine, figure 13, the cylinders are arranged in blocks of three, each block being provided with a common water jacket. The bore and stroke are 5.71ins. and 7.48 ins. respectively. The petrol consumption at ground level is 0.5lbs. per B.H.P. hour and the oil consumption 0.062lbs. per B.H.P. hour. The cylinder head casting is made of aluminium alloy. Two exhaust valves and one inlet valve are provided situated vertically in the cylinder crown and the bronze valve seats are screwed and shrunk into the cylinder heads, as are also the steel cylinder liners. The engine is developed from the earlier Galloway B.H.P., the chief feature of difference being the aluminium heads instead of cast iron which was used in the Galloway B.H.P. The compression ratio and r.p.m. are also somewhat higher. The radical difference between this and the German engines was the use of the aluminium cylinder head.

Of the engines of Italian origin, the latest during the war period was the 300 H.P. Fiat, known as A[12]bis, which hardly shows the same progress in design as the later British and German engines of the same type.

The salient points of design of the German engines were steel cylinders and welded jackets and the adoption of either long push rods or overhead camshaft compared with the aluminium heads and jackets and overhead camshaft of the British. In the bulk, the great majority of all German engines were of this type, while we used but two, though one, the Puma, was produced at the rate of 600 per month at the end of the war.

The steel type was probably on the whole the more reliable in quantity production whilst the aluminium was, in the main, lighter. Thermodynamically the German engines appeared to be somewhat superior, due to the development of one type with larger cylinders. The German engines had also to undergo severe tests before acceptance.

For engines of higher powers, it would appear that the Allies preferred to go to other types, especially the water-cooled Vee; and it may be said that the most serious development of engines for production both in this country and in France was in the latter type.

Particulars of this type are shown in Tables 9, 10, and 11. Although at the beginning of the war some of the engines such as the Wolseley-Renault and R.A.F. engines were air-cooled, the more recent examples have all been of the water-cooled type. The arrangement of the cylinders of Vee engines is not well adapted to the provision of adequate wind speed over all parts of the cylinder, and in recent practice air-cooling has been mostly confined to engines of the rotary and static radial types in which one set of cylinders is not screened by another from the wind, due to propeller slip stream and the forward movement of the machine: this arrangement of the cylinders gives ample space for heat dissipating fins, ensuring more even cooling of all.

In the earlier years of the war the available knowledge of air-cooling was somewhat meagre. Investigations undertaken at Farnborough, with a view to avoiding

TABLE 9

8-Cylinder Vee Type Water-Cooled Engines.

Make of Engine.		Wolseley	Hispano	Hispano	Hispano	Wolseley Viper
Arrangement of Cylinders ..		90°v.	90°v.	90°v.	90°v.	90°v.
Rated Horse Power	H.P.	130	150	200	300	180
Number of Cylinders	No.	8	8	8	8	8
Bore of Cylinders	Ins.	5.00	4.72	4.72	5.51	4.72
Stroke of Pistons	Ins.	7.00	5.12	5.12	5.91	5.12
Total Swept Volume of Engine ..	Cu. Ins.	1100	718	718	1127	718
Compression Ratio	R.	—	4.8	4.8	5.34	5.30
Brake Horse Power	B.H.P.	133	165	208	300	220
Revolutions per Minute	R.P.M.	1200	1600	2000	1800	2000
Piston Speed in Feet per Minute	Ft./Mn.	1400	1280	1706	1770	1706
Brake Mean Pressure	B.M.E.P.	79.86	114.0	115.0	116.8	121.8
Fuel per B.H.P. Hour	Lbs.	0.590	0.500	0.540	0.576	0.520
Oil per B.H.P. Hour	Lbs.	0.100	0.040	0.067	0.040	0.056
Brake Thermal Efficiency. (18600 B.T.US. per lb.)	%	23.2	27.4	25.3	23.75	26.3
Weight of Engine complete with Cooling System	Lbs.	700	551	638	795	657
Weight per B.H.P.	Lbs.	5.30	3.30	3.10	2.60	3.10

TABLE 10.

12-Cylinder Vee Type Water-Cooled Engines.

Make of Engine		R.A.F 3A.	Renault	Rolls-Royce. Eagle	Rolls-Royce. Falcon	Rolls-Royce. Eagle	Liberty 12A.	Sunbeam Maori
Arrangement of Cylinders ..		60°v.	50°v.	60°v.	60°v.	60°v.	45°v.	60°v.
Rated Horse Power	H.P.	220	220	225	220	360	400	250
Number of Cylinders	No.	12	12	12	12	12	12	12
Bore of Cylinders	Ins.	4.49	4.92	4.50	4.00	4.50	5.00	3.94
Stroke of Pistons	Ins.	5.51	5.91	6.50	5.75	6.50	7.00	5.31
Total Swept Volume of Engine ..	Cu.In.	1047	1348	1240	868	1240	1650	776
Compression Ratio	R.	4.75	4.36	4.53	5.30	5.30	5.30	5.60
Brake Horse-Power	B.H.P.	220	225	254	270	350	405	265
Revolutions per Minute	R.P.M.	1700	1300	1800	2200	1800	1650	2100
Piston Speed in Feet per Minute	Ft.Mn.	1563	1081	1950	2108	1950	1925	1860
Brake Mean Pressure	B.M.E.P.	98	100	90	114	124	118	125
Fuel per B.H.P. Hour	Lbs.	0.56	0.53	0.57	0.53	0.50	0.49	0.51
Oil per B.H.P. Hour	Lbs.	0.022	0.061	0.026	0.029	0.028	0.033	0.026
Brake Thermal Efficiency. (18600 B.T.US. per lb.)	%	24.43	25.81	24.09	25.81	27.36	27.93	26.83
Weight of Engine complete with Cooling System	Lbs.	936	951	1065	912	1177	1088	1065
Weight per B.H.P.	Lbs.	3.60	4.20	4.20	3.38	3.37	2.69	3.95

TABLE 11.

Air-Cooled, Vee Type Engines.

Make of Engine.		Wolseley Renault	R.A.F. 1A.	R.A.F. 4A.	R.A.F. 4D.
Arrangement of Cylinders		90°v.	90°v.	60°v.	60°v.
Rated Horse-Power	H.P.	80	100	150	180
Number of Cylinders	No.	8	8	12	12
Bore of Cylinders	Ins.	4.13	3.94	3.94	3.94
Stroke of Pistons	Ins.	5.12	5.51	5.51	5.51
Total Swept Volume of Engine	Cu. Ins.	549.5	536.8	805.2	805.2
Compression Ratio	R.	4.16	4.20	4.2	4.7
Brake Horse Power	B.H.P.	102	90	160	196
Revolutions per Minute	R.P.M.	1800	1600	1800	1800
Piston Speed in Feet per Minute	Ft./Mn.	1538	1470	1654	1654
Brake Mean Pressure	B.M.E.P.	82.0	83	87.7	107.0
Fuel per B.H.P. Hour	Lbs.	0.660	0.700	0.675	0.532
Oil per B.H.P. Hour	Lbs.	0.055	0.056	0.067	0.054
Brake Thermal Efficiency (18600 B.T.U. per lb.)	%	21.05	19.55	20.27	25.72
Weight of Engine complete	Lbs.	500	468	637	670
Weight per B.H.P.	Lbs.	4.90	5.20	3.98	3.42

overheating, which had been found to occur in the R.A.F. 1a and 4a engines, led to very important results.

At the beginning of the war the Wolseley Company were building a water-cooled motor of this type in this country on similar lines to the Renault in France. This developed a normal B.H.P. of 133 at 1,200 r.p.m. with a B.M.E.P. of 79.9lbs. per square inch and piston speed of 1,400 feet per minute; the weight per B.H.P. was 5.3lbs. This Company also built an air-cooled engine of the Renault type, the largest of which at this date gave 80 B.H.P. The engine most in the public eye in the early days of the war was the 8-cylinder R.A.F. 1a; an air-cooled design first built at Farnborough, though afterwards built by many contractors. This engine had cast iron cylinders with valves in side pockets; the cylinders were staggered so that independent connecting rods could be employed, a construction which was not followed in later engines. The pistons were of cast iron with cast iron rings and the crankcase of aluminium The propeller shaft was driven at half-engine speed by spur gearing, which also drove the camshaft which was co-axial with it. Only a single thrust bearing was employed so that the engine could only be used as a tractor. The inlet valves were directly operated while the exhaust valves were actuated by rocker levers and push rods from a camshaft with cams cut solid with the shaft housed in the crankcase between the rows of cylinders. Lubrication was by gravity and splash. This engine had roller bearings to its crankshaft and this was probably its most novel feature. It was at the last a very reliable engine, but always too low in power for the work on which it was employed.

The Hispano Companies have been most prominent in the development of the eight-cylinder type, and very large numbers of engines of 200 H.P. of the Hispano type were built by many companies in France and Great Britain. The latest form of the Hispano, the 300 H.P. engine, is the most compact engine of its type and power yet produced. This engine develops 300 B.H.P. with a B.M.E.P. of 116.8 at 1,800 r.p.m., piston speed 1,770 feet per minute, and weight 2.60lbs. per B.H.P. The very high speeds of these engines necessitate the use of gearing in order to obtain practicable propeller efficiency, except in very fast scouting machines.

In this type, the cylinders were of steel screwed into a monobloc aluminium water jacket, the inlet and exhaust ports being arranged in the aluminium casting Tubular connecting rods are used, one of each pair having a forked big end which

runs on the outer surface of the other. Overhead valves are used and are operated by an overhead camshaft, the cams acting directly on the valve stems, a form of valve gear particularly suitable for a high speed engine.

The Sunbeam Company also have built engines of this type which were extensively used. The earliest of these, with eight cylinders of 90 mm. bore, and 150 mm. stroke, was fitted with valves in side pockets, and developed 145 B.H.P. at 2,100 r.p.m., and weight per horse-power 4.3lbs. An engine of the same type with slightly larger stroke, 160 mm., developed 170 B.H.P. at 2,000 r.p.m., with weight per horse-power 3.75lbs. Later an overhead valve type was produced with cylinder 120 mm. bore and 130 mm. stroke, giving 200 B.H.P. at 2,100 r.p.m., with a weight per horse-power of 3.16lbs. In all of these, gearing was employed to reduce the propeller speed to about 1,000 r.p.m.

The twelve cylinder Vee engines were very largely used by the Allies, and in this country underwent extensive development, particularly marked in the engines produced by the Rolls Royce Company, two of which were employed in the successful Vickers Vimy Atlantic flight. The steady increase in power and reliability obtained by this firm in their series of engines by means of improvements in the design, proved by experience to be desirable, is very remarkable and would seem to show that important results could be obtained by the application of similar methods and high technical ability to engines of types which have undoubtedly inherent advantages, but are still in a comparatively backward state of development.

The Rolls Royce series of Eagle and Falcon engines, 12 cylinder 60° Vee, have reached very great reliability. In the Eagle series the bore is 4.5″ and stroke 6.5″; in the Falcon 4.0″ and 5.75″ respectively. The cylinder construction and valve operation are similar to the Mercedes. The connecting rods are of the articulated type. The high speed of the engines necessitates reduction gearing.

An early example of the 12-cylinder 60° Vee water-cooled type is the R.A.F. 3a 220 H.P. The cylinders with their heads and valve ports are machined from solid steel forgings, with sheet steel water jackets welded in position. The inlet and exhaust valves are in the cylinder head, and are actuated by a single rocker and push rod from a camshaft lying along the Vee, co-axial with and driven by dogs from the propeller shaft. The crankshaft runs in roller bearings, and drives the propeller shaft at half speed through spur gearing. The connecting rods are of the articulated type, and aluminium pistons with cast iron rings are employed.

The R.A.F. 4a was largely used throughout the war. Air-cooling is employed, the cylinders being of cast iron with integral cooling fins, and valves in side pockets formed on the inner sides of the cylinders. The engine is developed from the R.A.F. 1a eight-cylinder, and is of very similar construction.

The 240 H.P. Renault is a French water-cooled engine, with 12 cylinders inclined at 50°; bore 124 mm., stroke 150 mm., and a normal speed of 1,200 r.p.m. Little development of this type took place in France.

The Liberty, fig. 14, produced in large quantities in the United States, is a 12-cylinder 45° Vee; the cylinder construction closely follows the Mercedes and Rolls-Royce designs; overhead valves and camshaft of a similar type are employed. The crankshaft journal bearing caps are cast in one with the lower half of the crank-case. The connecting rods are of the direct bearing type, one of each pair being forked at the big end to allow both to bear directly on a phosphor bronze shell on the crank pin. In the design of this engine, special attention was given to ease of production, and ultimately considerable success was achieved.

The Sunbeam Company also produced a number of 12-cylinder water-cooled Vee engines, the best known of which is the Maori, used in the airship R34 in the Atlantic crossing. The two banks of cylinders are inclined at 60° to each other, and are each provided with four overhead valves actuated by two camshafts driven through trains of spur gearing; the connecting rods are of very light H section. As weight is of secondary importance in airship work, a fly-wheel is fitted to the crankshaft. A governor is fitted, which cuts out the ignition when the engine speed reaches 2,500 r.p.m., or when the oil pressure falls below 20lbs. per square inch.

It will be seen that of water-cooled Vee types we had two classes; steel cylinders with steel jackets welded on, and aluminium

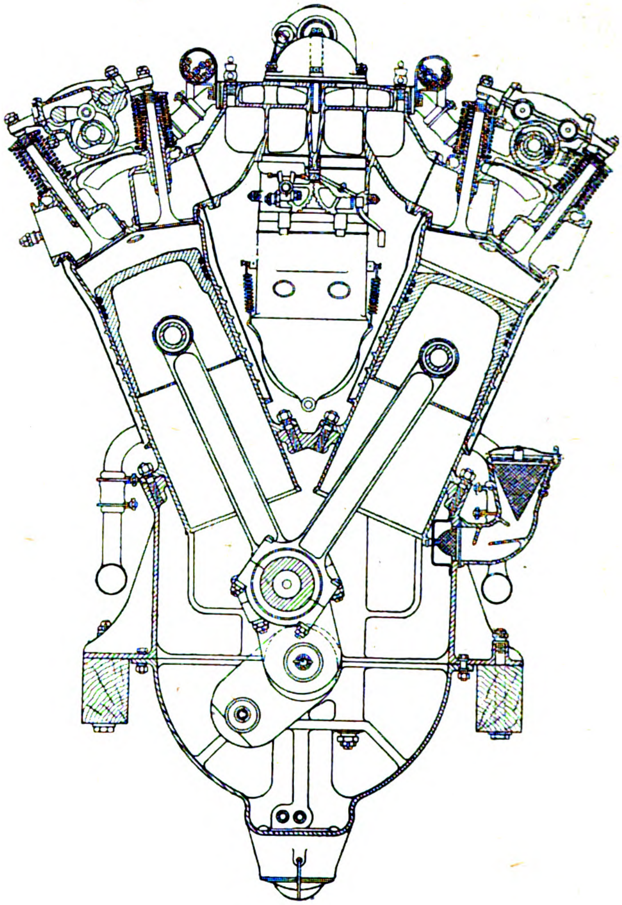

FIG. 14.

jackets with steel liners. In practice, the former, used in the Rolls engines proved probably more reliable and the latter method the lighter. The latter was used in high speed scouts and the former in longer formation flights and larger machines. Both types used overhead valve gear, in the latter the cams operating direct on the valve spindles.

In the air-cooled engines of this type the cast iron cylinders kept the weight high; the most novel point was the use of roller bearings for the crankshaft.

As regards the fan or three row type, little progress was made for some time after the original three cylinder Anzani and R.E.P. The first engine of high power of this type produced was the Sunbeam 18-cylinder 450 H.P. Viking, with three rows each of six water-cooled cylinders, the angles between the rows being 40°. The bore and stroke are 110 mm. and 160 mm., and the cylinders are cast in blocks of three, with two inlet and two exhaust valves per cylinder operated by two camshafts on each row. Master connecting rods are fitted for the central row of cylinders, and articulated rods for the side rows. Six carburettors are employed, each supplying a block of three cylinders. Each camshaft of the central row of cylinders operates the exhaust valves of one block of the central row and the inlet valves of the other block, the exhaust valves being on opposite sides on the two central cylinder blocks.

The latest development of the three row type is the Napier Lion, fig. 15, which has achieved very considerable success since the war. This engine was originally designed to work at full throttle at a height of 10,000 feet only, and to give not less than 300 H.P. at that altitude. As actually built, these engines are capable of running at full power at ground level. The engine

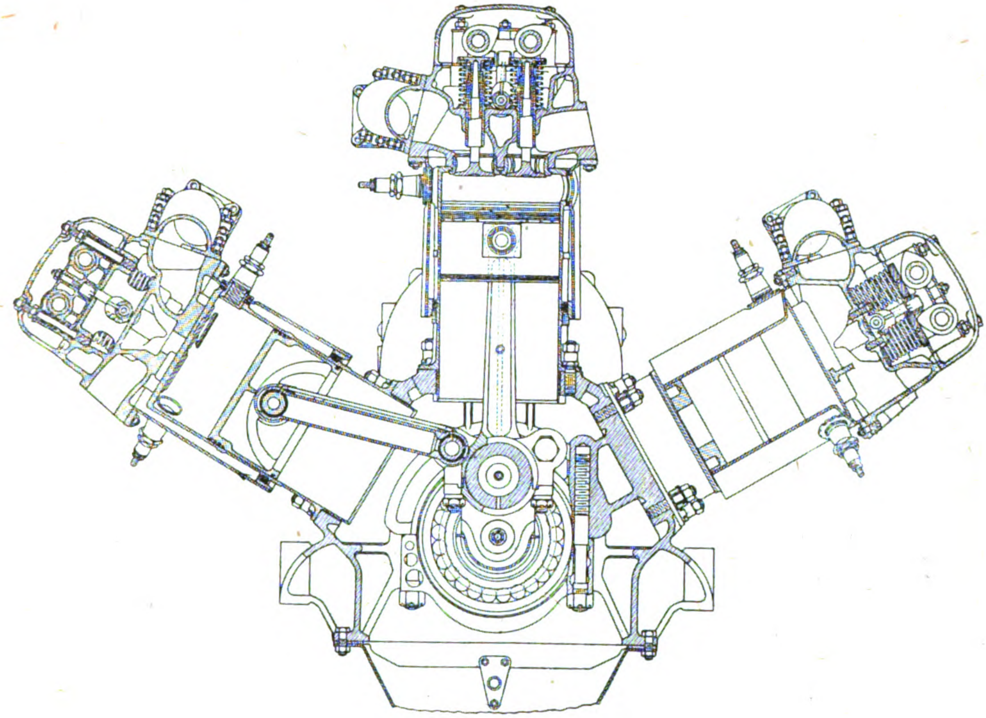

FIG. 15.

has three rows at 60° of four separate cylinders of $5\frac{1}{2}''$ bore by $5\frac{1}{8}''$ stroke, with a compression ratio of 5.55, and normal B.H.P. 450 at 2,000 r.p.m. with B.M.E.P. 122lbs. per square inch. The weight is 2.56lbs. per B.H.P. Fuel consumption is .504lbs. per B.H.P. hour, and oil consumption .022lbs. per B.H.P. hour. This form of construction enables a short engine of high power to be built. The engine is of interest in that it uses a high compression ratio, and in that the design is of the oversized type, the cylinders being designed to work at reduced atmospheric pressure with other parts proportionally reduced in weight. It must be remembered, however, that the total weight of the engine involves many parts in which the limiting strength is determined by inertia considerations, which are independent of gas pressures; also many parts must be dimensioned with a view to casting considerations and certain minimum thicknesses must be allowed, so that the reduction of weight obtainable by so called light and over-sized design is not so great as might be supposed.

Further interesting features of the Napier Lion are the use of roller bearings for the crankshaft to reduce bearing loading difficulties as in the R.A.F. engines, and Hispano camshafts operating directly on the valve stems.

Type 4, the Cross type, did not come into service during the war, though engines were constructed in England, by Messrs. Leyland Motors and the Aircraft Manufacturing Company; in France by Clerget and Anzani; in America by the Trebert Company.

The rotary air-cooled engine, Type 5, was very largely used, and up to powers of about 230 B.H.P. has been found to be quite satisfactory. The particulars of the chief engines of the type are shown in Table 12.

The early Gnome type was followed by the 100 H.P. Monosoupape Gnome, fig. 16. The distinctive feature of this engine is the induction arrangement by which rich mixture is introduced to the cylinder from the crankcase through ports uncovered by the piston, the charge being made up by air taken in through the exhaust valve in the cylinder head. This valve is operated by a push rod by means of nine cams driving from the rotating crankcase by an epicyclic gear. A noteworthy feature of this construction is the low gas velocity obtained by the use of the single valve. Subsequently

TABLE 12.

ROTARY ENGINES.

Make of Engine.		Gnome	Monosoupape Gnome		Le Rhone	Clerget.	B.R.1	B.R.2
Rated Horse-Power	H.P.	80	100	150	110	130	150	200
Number of Cylinders	No.	7	9	9	9	9	9	9
Bore of Cylinders	Ins.	4.88	4.33	4.55	4.41	4.72	4.72	5.51
Stroke of Pistons	Ins.	5.51	5.91	6.69	6.69	6.30	6.69	7.08
Total Swept Volume of Engine ..	Cu.In.	748	783	987	920	994	1055	1522
Compression Ratio	R.	4.30	4.90	5.42	4.82	4.56	5.09	5.30
Brake Horse-Power	B.H.P.	68.5	104	152	110	127	156	238
Revolutions per Minute	R.P.M.	1150	1200	1250	1200	1250	1250	1300
Piston Speed in Feet per Minute	Ft.Mn.	1095	1180	1392	1340	1312	1394	1536
Brake Mean Pressure	B.M.E.P.	63.0	87.7	97.6	78.9	81.0	94.0	95.2
Fuel per B.H.P. Hour	Lbs.	0.787	0.690	0.634	0.560	0.60	0.59	0.63
Oil per B.H.P. Hour	Lbs.	0.190	0.180	0.112	0.091	0.123	0.109	0.074
Brake Thermal Efficiency. (18600 B.T.U. per lb.)	%	17.4	19.8	21.6	24.4	22.8	23.2	21.7
Weight of Engine Complete ..	Lbs.	224	288	313	336	400	405	498
Weight per B.H.P.	Lbs.	3.27	2.77	2.06	3.06	3.15	2.60	2.10

an engine of 150 H.P. of similar design was built and gave good results.

The Le Rhone engine, which was also largely used, has been already described, and except as regards power has undergone little modification.

The Clerget engines are noteworthy in respect of the valve operating gear employed, which has been adopted in the later BR1 and BR2 engines. The cylinders are machined from solid steel billets, as in the Gnome engines.

The BR1 engine, designed in Great Britain, is very similar to the Clerget, the only substantial novelty in its design being the construction of the cylinders, with cast aluminium barrels shrunk on to cast iron, and later steel liners. The cylinder heads are machined in steel with the induction pockets in one piece, and are held down by bolts inserted from the inside of the crankcase. The design of the cooling surface leaves something to be desired in comparison with more recent air-cooled cylinders. This engine, however, showed good reliability in service.

The BR2 engine, developed from the BR1 to meet demands for increased power, differed from the earlier BR1 in the use of steel instead of cast iron for the liners; in other respects the design is similar.

With regard to engines actually in service during the war, it may be said that development of the rotary has merely taken the line of eliminating obvious defects, and improving the cylinder construction to a certain extent by suiting the design to the use of materials of higher heat conductivity. Improvement in design in this respect was not, however, carried to the extent which has been shown to be possible by the experiments carried out at the R.A.E. Farnborough. The rotary type was not accepted as a final type, and thus escaped to some extent the close attention given to other designs. The gyroscopic effects and heavy windage losses are against it.

It may be said that the rotary did not develop in production many points of novelty. The peculiar cycle of the single valve Gnome is one to which attention may be drawn. This principle may possibly be further developed.

The radial engines, Table 13, offer advantages as regards weight for power. It has been shown that such engines, even on our present knowledge, can be built of a lower weight per B.H.P. than any of the other types, and although their reliability has not as yet come up to the standard reached by the water-cooled vertical and Vee types, their advantage in weight leaves open possibilities of their attaining considerable commercial use, with a weight per horse-power lower than that obtainable with other types, which have already been developed to a more advanced stage. Water-cooling may be

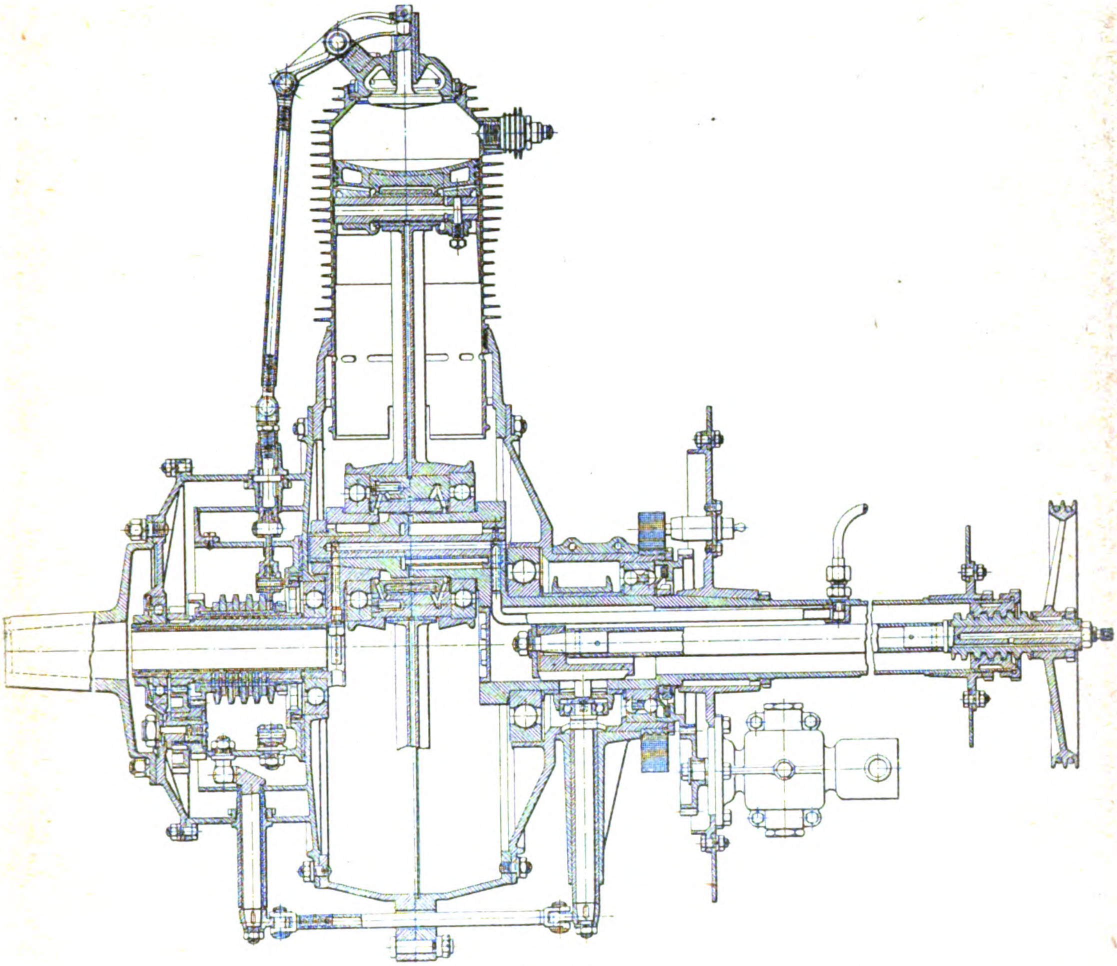

FIG. 16.

employed in radial engines, as in the Canton Unné, which was extensively used early in the war, but the radial type offers such great advantages as an air-cooled engine that for engines of powers up to 500 B.H.P. water-cooling would not seem to offer any advantage. Possibly water-cooling may raise the size of radial engines; though the limit of size with air-cooled cylinders has not yet been reached.

The only example of the air-cooled radial in service at the commencement of the war was the Anzani. The 125 H.P. of this type has ten cylinders arranged in groups of five about a two-throw crankshaft, the bore and stroke being 4.53″ and 5.93″ respectively, with a brake mean pressure of 86.2lbs. at 1,200 r.p.m. The fuel consumption was not excessive, being only .57lb. per B.H.P. hour; a very creditable performance with the knowledge of air-cooling available at that date. It will be noticed that this two-throw type of radial has the advantage that the balance weights necessary in the single row radial are not required. The weight was, however, somewhat hig h,amounting to 3.7lbs. per horse-power, due to the low B.M.E.P. which was 86.2; with a B.M.E.P. of 110lbs. per square inch, the weight per horse-power would become 2.9lbs.

Very early in the war an air-cooled radial, the Smith Static, was used to some extent. The engine had 10 cylinders, 4.53″ bore and 6.10″ stroke. These were all placed in one plane; slanting connecting rods were used working on a two-throw crankshaft. A special fan arrangement was used for cooling. The compression ratio was 4.5 to 1 and the normal B.H.P.

TABLE 13.

RADIAL ENGINES.

Make of Engine.		Anzani.	Mark II. Wasp.	Mark II. Dragon Fly.	Jupiter.
Rated Horse Power	H.P.	100	150	320	400
Number of Cylinders	No.	10	7	9	9
Bore of Cylinders	Ins.	4.13	4.5	5.5	5.75
Stroke of Pistons	Ins.	5.71	6.0	6.5	7.50
Total Swept Volume of Engine	Cu. Ins.	766	668	1390	1753
Compression Ratio	R.	4.48	4.00	4.51	5.00
Brake Horse Power	B.H.P.	100	153	294	400
Revolutions per Minute	R.P.M.	1200	1800	1650	1650
Piston Speed in Feet per Minute	Ft./Min.	1140	1800	1790	2060
Brake Mean Pressure	B.M.E.P.	83.0	99.1	101.5	109.5
Fuel per B.H.P. Hour	Lbs.	0.535	0.603	0.645	0.500
Oil per B.H.P. Hour	Lbs.	0.135	0.020	0.030	—
Brake Thermal Efficiency. (18600 B.T.U. per Lb.)	%	25.58	22.70	21.21	27.36
Weight of Engine Complete	Lbs.	398	294	670	700
Weight per B.H.P.	Lbs.	3.98	1.92	2.54	1.75

150; this power being developed at 1,300 r.p.m. The fuel consumption was 0.53lb. per B.H.P. hour and the oil consumption 0.062lb. per B.H.P. hour. The B.M.E.P was 92lbs. per square inch.

Later engines of the radial type, the Wasp and the Dragonfly, which were not brought into full service use, show considerable advance. In these engines, one piece solid-ended steel cylinders are employed with two exhaust valves and one inlet valve per cylinder. The heads are flat and of the same diameter as the barrels, with separate cast iron and aluminium castings for the exhaust and inlet ports and valve guides. Cylinders designed at the R.A.E. and fitted to these engines have given much improved results. The increased mean pressures may increase the mechanical difficulties due to the heavy loading of the single crank pin.

The Jupiter radial of the Bristol Company, to some extent avoided the overheating difficulties by forming the ports and valve guides in an aluminium casting attached to the top of the barrel, which is considerably enlarged at the combustion chamber end, giving a large surface of contact between the aluminium and steel. In this engine also the distribution was improved by a special type of distributor, by which separate mixture supplies are led to the cylinders in three groups. None of these engines, however, quite attained the results since shown to be possible by the use of cylinders designed from the experimental work carried out at the R.A.E.

The later radial engines did not have war service and their mechanical details were not so well tried out.

With regard to the differential type, the only engine which came into service was the Siemens-Halske 200 H.P., an eleven-cylinder engine of bore and stroke 4.88" and 5.51", with a compression ratio of 4.95 to 1, giving 193 B.H.P., with a B.M.E.P. of 96.2lbs. at 1,400 r.p.m., and a fuel consumption of .64lb. per B.H.P. hour; at 1,800 r.p.m. the B.H.P. was 204 and the B.M.E.P. fell to 79lbs. per square inch. The engine is geared so that cylinders and crankshaft rotate in opposite directions at the same speed. The weight per B.H.P. at 1,600 r.p.m. was 2.24lbs.; a higher value than that of British rotary engines of about the same power. The cylinders were of steel with integral heads, with single inlet and exhaust valves operated by push rods and rockers. This engine shows no advantage over the existing British and French rotaries. In this country the author, in 1915, designed engines of the differential type, and subsequently an eight-cylinder six-stroke engine of 250 H.P. was constructed, fig. 17. The total weight was 400lbs., or 1.6lbs. per horse power. It was estimated from the perform-

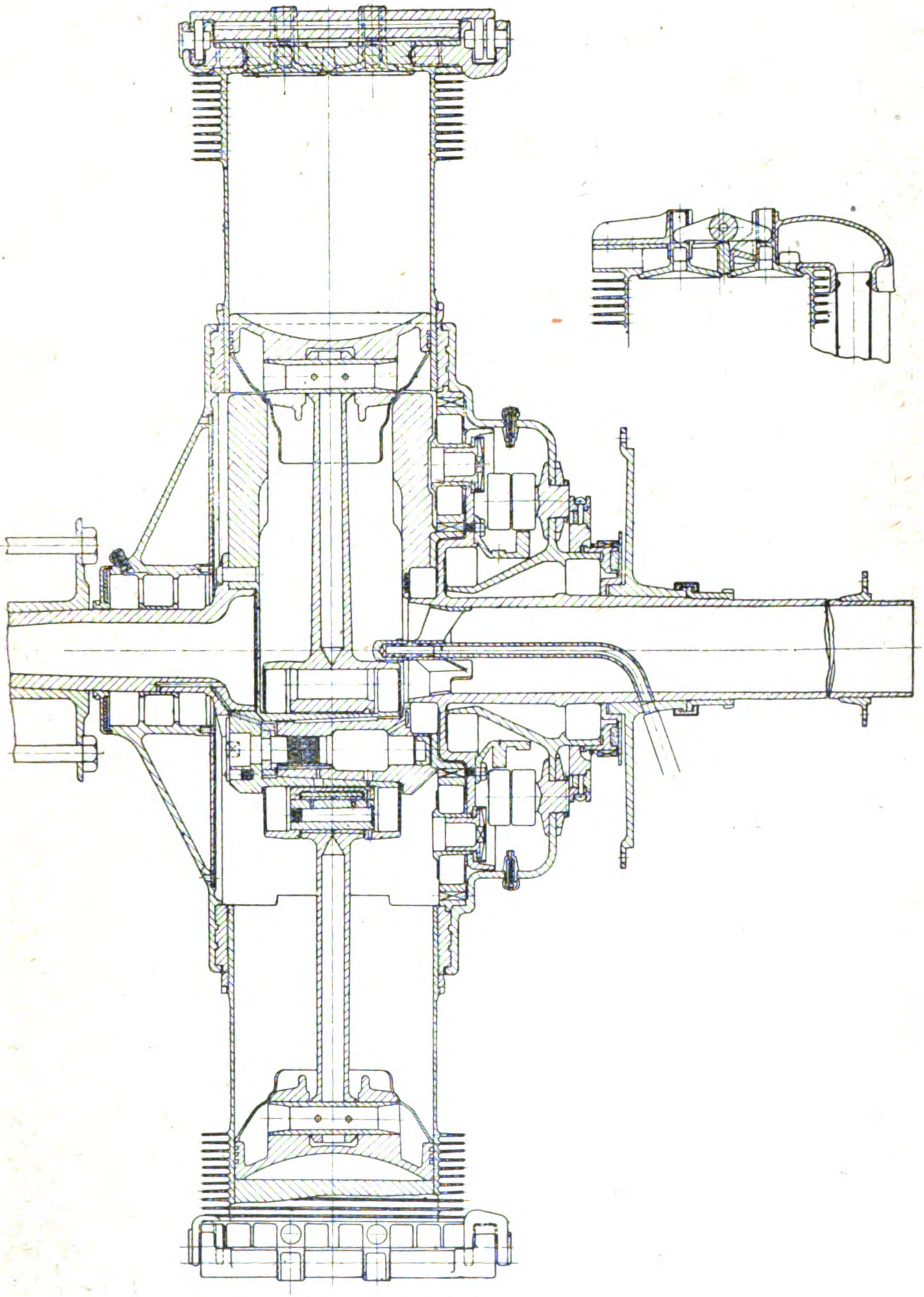

Fig. 17.

ance of this engine that an engine on similar lines, working on the four-stroke cycle could be constructed at the extremely low weight of 1.11lbs. per B.H.P. Subsequently, Dr. Blackwood Murray, using the designs and results of previous experiments, designed an engine to give 600 H.P. with a piston speed of 2,500 feet per minute, and weight of 610lbs., or just over 1lb. per B.H.P. This was not, however, proceeded with.

It will now be of interest, before dealing with matters which may be said to be still experimental, to tabulate the results obtained in the different types by engines which had reached the stage at which production in quantity was considered expedient. The results given in Table 14 are examples selected as being approximately the maximum obtained in ordinary practice in production engines at the end of the war.

Many engines of various experimental types have been built during the war, but have not yet reached the stage of development at which production is justified.

One important class of these has been designed with the object of producing engines capable of approaching their normal ground level output when working at the lower atmospheric densities existing at high altitudes.

Four main methods of effecting this have been proposed :—

(1) Supercharging, *i.e.*, admitting to the cylinder an additional charge of air or exhaust products or both at the end of the suction stroke at a pressure of a few pounds above the existing atmospheric pressure.

(2) Forced induction, compressing air taken in at the existing atmospheric density before leading it to the cylinder so that the inlet pressure at high altitude approximates to atmospheric density at ground level.

(3) Design for low atmospheric pressure with restricted output at ground level.

(4) Increasing the compression ratio at altitude by varying the stroke or other means.

The first method is a development of the air and exhaust gases supercompression gas engines proposed by Sir Dugald Clerk in order to obtain high mean pressures with maximum pressures and temperatures lower than those reached in normal four-stroke engines when working on gases of high hydrogen content, particularly in large cylinders. In Clerk's exhaust supercompression engine the piston was arranged to overrun ports round the cylinder at the outer end of the stroke. The exhaust gas passed from the cylinder through these ports to a water jacketed annular space and through a long cooled pipe to a reservoir, a sufficient quantity of exhaust gas being allowed to pass to keep the pressure in this reservoir above that of the atmosphere. A piston valve was arranged to close the inlet

TABLE 14.

SOME COMPARATIVE RESULTS.

Type of Engine.		Vertical.	Vee.		Vee.		Arrow.	Rotary	Rotary	Radial
Cooling System ..		Water	Water		Air.		Water	Air	Air	Air
Number of Cylinders	No.	6	8	12	8	12	12	9	9	9
Bore of Cylinders ..	Ins.	5.71	5.51	4.50	3.94	3.94	5.50	4.51	5.51	5.75
Stroke of Pistons ..	Ins.	7.48	5.91	6.50	5.51	5.51	5.125	6.69	7.08	7.50
Brake Horse Power	B.H.P.	240	300	350	90	196	450	152	238	400
Revolutions per Min.	R.P.M.	1400	1800	1800	1600	1800	2000	1250	1300	1650
Brake Mean Pressure	lbs sq″	118.1	117	124	83	107	122	97.6	95.3	109.5
Piston Speed in Feet per Minute ..	Ft.Mn.	1746	1770	1950	1470	1654	1708	1392	1536	2060
Fuel per B.H.P. Hour	Lbs.	0.500	0.587	0.50	0.700	0.532	0.495	0.634	0.630	0.500
Oil per B.H.P. Hour ..	Lbs.	0.062	0.040	0.028	0.056	0.054	0.022	0.112	0.074	—
Weight per B.H.P. complete with Cooling System ..	Lbs.	3.25	2.37	3.3	5.20	3.42	2.52	2.06	2.10	1.75

to the reservoir before the main exhaust valve opened. On the next stroke, immediately after the charge inlet valve was closed the piston valve was opened allowing some of the cooled exhaust gas from the reservoir to flow by another pipe to the cylinder raising the pressure to about 3lbs. above atmosphere. Clerk also suggested that temperature in large gas engine cylinders might be kept down by scavenging with cooled exhaust gas.

During the war proposals were made to apply supercharging to a B.H.P. engine and also to a Brotherhood engine; but did not lead to further construction. Subsequently an engine was designed by Mr. H. Ricardo and built in the form of a 300 H.P. 12-cylinder water-cooled Vee engine with the banks of cylinders inclined at 30°. A crosshead piston is employed and alternately draws in and compresses air in the closed space below it; the piston overruns ports in the cylinder as in the Clerk engine and a portion of the exhaust products pass through the cooled passage to the space below the piston into which the air has been drawn during the previous compression stroke. No valve other than the ports overrun by the piston is employed to control the flow of the exhaust products from and to the cylinder and air is drawn in through an automatic valve during each instroke of the piston. The cooled exhaust gases form only a small proportion of the super-charge which consists mainly of air, and the hot gases which would normally remain in the cylinder at the end of the exhaust stroke are displaced by cooled exhaust gas and a considerable proportion of air. A single cylinder unit of 110 mm. bore and 140 mm. stroke with a compression ratio of 5 to 1 running at 1,500 r.p.m. developed 16.6 B.H.P. without supercharge and 22.4 B.H.P. with supercharge and correspondingly increased fuel supply at the same speed.

With regard to the second method, forced induction, a considerable amount of work has been done at the R.A.E., Farnborough, and also in Germany and the United States.

Good results have been obtained with a blower running at a high speed mounted on the shaft of an exhaust driven turbine. This was first proposed by Prof. Rateau in France, and promising results have been obtained with experimental units at the R.A.E. and also in France and the United States. A blower of this type applied to a Liberty engine has been tested at the R.A.E. and has shewn that ground level power can be maintained to heights of 20,000 feet or more.

This method will probably be found the most suitable for very high altitudes.

As regards the third method, engines have been designed with a specially high compression ratio for altitude and some of these have come into service, for example, the Napier Lion in this country and many airship engines, and also the Bayern engine in Germany. So far as the author is aware, the compression has not been carried to the high value which would be possible with satisfactory means for limiting output at ground level, though for moderate altitudes it would appear to provide the most satisfactory solution of the problem. With regard to the fourth method, variable compression, so far as the author is aware, there were few, if any, aero engines in operation in which variable compression was employed.

Many experimental types of engines were proposed during the war; but for the most part they would have required prolonged research and experiment before they could reach the stage of development at which production in quantity could be justified. It may be of interest to mention a few of these proposals.

Although no aero engine working on the two-stroke cycle has reached the production stage, a number of different types have been proposed. Engines working on the two-stroke cycle were built by the New Engine Company in 1912. These engines were produced in two sizes, namely 50 H.P. and 100 H.P. The 50 H.P. was a Vee type engine with 4 cylinders $3\frac{11}{16}$" bore and $4\frac{1}{2}$" stroke, developing 50 B.H.P. at 1,250 revs. per minute. The 100 H.P. engine had 6 vertical cylinders of 4" bore and $5\frac{1}{2}$" stroke. The weight of the engine with silencers bolted to the cylinders was 330lbs. It developed 100 B.H.P. at 1,250 revs. per minute. The fuel and oil consumption of these engines was stated to be approximately 0.58lb. and 0.026lb. per B.H.P. hour respectively. The mechanism provided for pumping in the fresh gas and driving out the exhaust was a special form of Roots Blower; it was divided so that one part dealt with pure air and the other with gas. A rotary valve, interposed between the blower and the cylinder controlled the

inlet and air only was admitted until all the exhaust products were expelled.

Another engine which may be mentioned is the Fredickson two-stroke rotary which was built in the United States with 3, 5, and 10 cylinders. In this engine the lower part of the cylinder is partitioned off to form a space in which the charge taken in from the crankcase is compressed. An oscillating slide valve controls the passage of the mixture from the crankcase to the compression chamber and from this to the cylinder.

Prof. Junker in Germany, has constructed a high speed two-stroke cycle engine with two pistons moving in opposite directions in each cylinder and controlling ports in the cylinder at the outer end of their stroke. Pure air scavenging and direct fuel injection are stated to be employed, a high pressure fuel pump regulating the mixture. A number of cylinders are placed parallel to each other with two parallel crankshafts at the ends of the cylinders. The propeller shaft is driven by a spur wheel gearing with spur wheels on the crankshafts.

The cooling of the pistons is effected by oil enclosed in cavities within them, so that the oil in violent motion carries the heat from the head of the piston to its sides and so to the cylinder walls.

Hirth is also stated to have tested a two-stroke cycle engine in which the exhaust gases are drawn off through a hollow steel propeller which at the same time serves to draw in the fresh charge; separate exhaust and inlet ports are successively uncovered by the piston.

The engine is intended to run at 2,400 r.p.m. giving 300-400 horse-power with a weight per horse power of 1.65 to 1.76lbs.

Another interesting experimental type is the swash-plate engine, one of which, known as the Perfetti Dolara, has been constructed in Italy in the form of a nine-cylinder air-cooled engine of 130 mm. bore by 176 mm. stroke. It is stated to give 300 B.H.P. at 1,500 r.p.m., with a weight of 2.05lbs. per horse-power.

Another of this type is the Motor La Meuse, a six-cylinder water-cooled stationary engine, 120 mm. bore by 140 mm. stroke, with cylinders parallel to the shaft axis and developing 125 horse power.

Oscillating cylinders have been employed in the Seja engine.

OBITUARY.

Senator Edmund Powell.—By the death of Mr. E. Powell, the Union of South Africa loses one who for many years had been prominent in the public life of that country. Born in Worcestershire in 1849, he left England in 1880, to join the staff of the *Cape Argus*, of which he became Editor in the following year. From 1904 to 1908 he sat for the Western Circle in the local Legislative Council, and subsequently entered the House of Assembly as representative of a Cape Town constituency. He resigned his editorship when the Unionists chose him to be a senator of the first Union Parliament. He was elected a member of the Royal Society of Arts in 1903.

GENERAL NOTES.

Hemp Production in Canada.—An effort is being made to encourage the sowing of hemp in the Prairie Provinces of Canada, with a view ultimately to producing there sufficient hemp from which to manufacture hemp fibre and products to replace those now imported. In 1920 there was sown in the vicinity of Winnipeg about 500 acres of hemp; tracts of land were also sown to hemp in the Provinces of Saskatchewan and Alberta, and in each locality good crops and good quality of hemp were produced. Owing to the shortness of the season in Western Canada, it is not anticipated that a sufficient quantity of seed will be grown there. According to the United States Consul-General at Winnipeg, seed is imported largely from Kentucky, but about 1,000 pounds will be imported this year directly from Italy.

Canada and India.—By means of new shipping services provided by the Canadian Government Merchant Marine and by expanding her trade commissioner services, Canada, says "*The Times* Trade Supplement," is making strenuous efforts to increase her overseas commerce. The latest development in this direction is the appointment of a Trade Commissioner in India with headquarters in Calcutta. Major H. A. Chisholm, M.C., hitherto Canadian Trade Commissioner in Cuba, has just been nominated as the first commercial representative of the Dominion in India, and he will take up his new duties during the autumn.

Indian Agricultural Progress.—A work on "Agricultural Progress in Western India," by Mr. G. Keatinge, C.I.E., I.C.S., will be published by Messrs. Longmans during the autumn. Mr. Keatinge read a paper on the same subject before the Indian Section of the Royal Society of Arts on January 16th, 1913.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Micro-Organisms and some of their Industrial Uses," by A. Chaston Chapman, F.I.C., F.R.S., have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been published separately, and are still on sale, can also be obtained on application.

CASES FOR JOURNALS.

Cases for keeping the current numbers of the *Journal* may be obtained post free, for 7s. 6d. each, on application to the Secretary. They are in red buckram, and will hold the issues for a complete year.

PROCEEDINGS OF THE SOCIETY.

HOWARD LECTURES.

AERO ENGINES.

By Alan E. L. Chorlton, C.B.E., M.Inst.C.E., M.I.Mech.E.

Lecture III.—*Delivered January 31st*, 1921.

There were several very interesting types of engines constructed during the latter days of the war or shortly after, some of very high power.

Of the 12-cylinder Vee type, there are the Galloway "Atlantic," which is substantially two "B.H.P." engines arranged as a Vee; the Siddeley Tiger, which has cylinders 160 m/m bore and 180 m/m stroke, giving 500 B H.P. at 1,500 r.p.m. ; the Rolls Royce "Condor," with cylinders having a bore and stroke of 5.5 inches and 7.5 inches respectively ; the B.H.P. developed is up to 600 at 1,750 r.p.m. Another large engine is the Sunbeam Sikh, which is stated to develop 850 H.P. at 1,400 r.p.m. ; the cylinder bore is 180 m/m and the stroke 210 m/m.

In France, Peugeot has produced an engine with a bore of 160 m/m and stroke of 170 m/m, which develops 600 H.P. at 1,600 r.p.m.

With regard to 8-cylinder Vee engines, the Hispano-Suiza now develops well over 300 B.H.P., and is the leading engine of this type.

The three-row or arrow type is now built by Lorraine Dietrich with 24 cylinders, having a bore of 126 m/m and stroke of 200 m/m. This engine develops 1,000 H.P.

The Cross type has been built by Peugeot in the form of a 16-cylinder water-cooled engine of 130 m/m bore by 170 m/m stroke.

A very interesting engine, completed just before the termination of the war, was the cross type designed by J. G. P. Thomas, of Messrs. Leyland Motors. (Figure 18). This engine had 8 cylinders ; developed 420 H.P. at 2,500 r. p. m., and its dry weight including dynamotor for starting purposes, was 550 lbs. or 1.31 lbs. per horse-power.

Of the Radial type reference may be made to the Armstrong-Siddeley, Anzani and F.I.A.T. engines.

The Armstrong-Siddeley is built in two sizes ; 150 H.P. and 300 H.P. These engines have a bore and stroke of 127 m/m ; they are both air-cooled and each develops its stated power at 1,500 r.p.m. A water cooled radial with twenty cylinders and capable of developing 600 H.P., has been produced by Anzani. In Italy the F.I.A.T. have constructed a water-cooled radial engine with 9 cylinders, 130 m/m by 150 m/m, which develops 300 H.P. at 1,800 r.p.m.

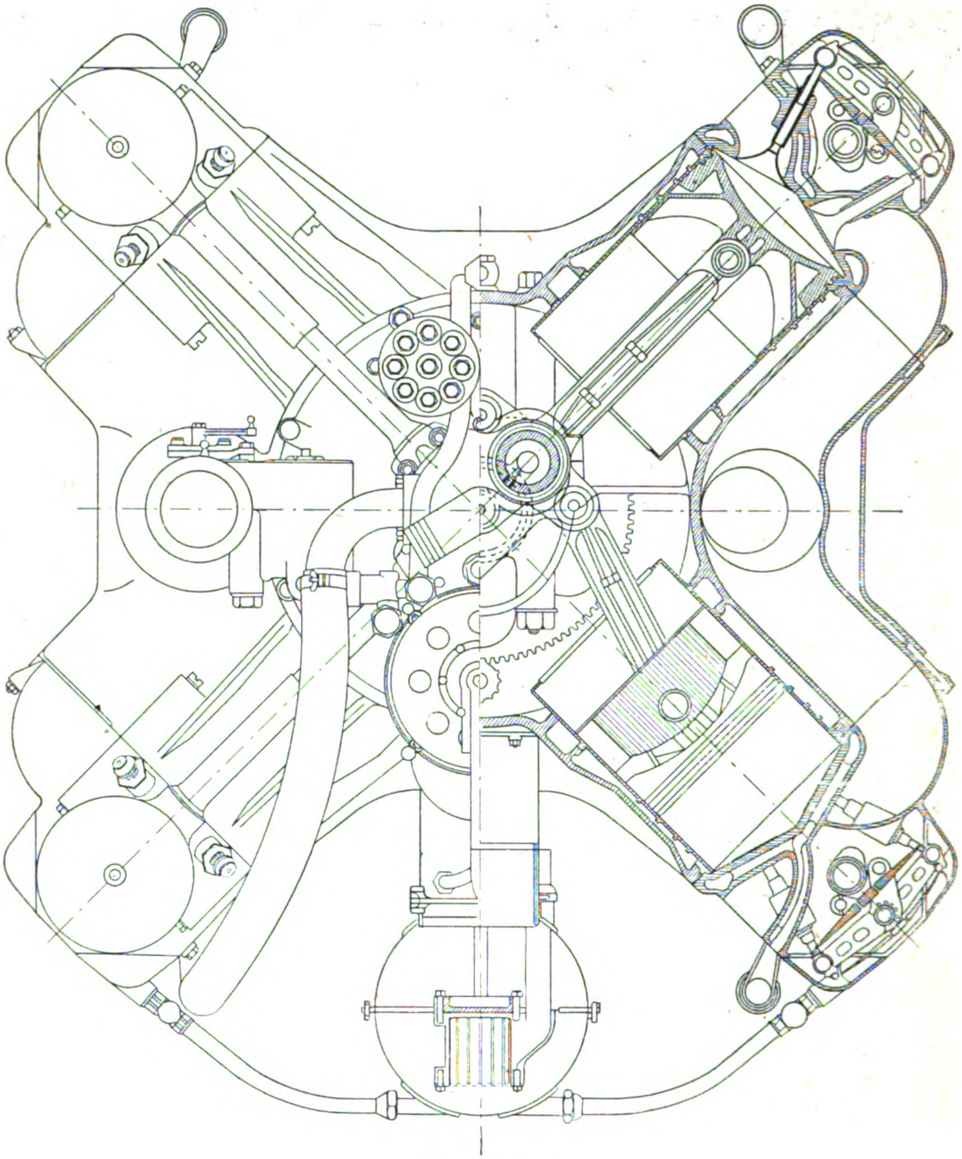

FIG. 18.

Other types and modifications of the main types have been proposed, and it will be obvious that many cylinder arrangements are possible, and no doubt, when the commercial prospects of aviation become more easy, we shall see a great renewal of activity in the production of new models.

In dealing with the future development of the aero motor, I think we may consider it with relation to a comparison of types of existing engines, as given in table 15.

We may discuss the progress that may be made under three headings :

(1) Thermodynamical.
(2) Mechanical.
(3) Metallurgical.

Taking thermodynamic considerations first, the present aero engines work almost universally on the four-stroke constant volume cycle, with equal compression and expansion, and any departures which have been made from this cycle may be regarded as purely experimental.

The best aero engines at the present day obtain thermal efficiencies of over 30% ; high compression land engines have reached

TABLE 15.

COMPARATIVE TABLE OF TYPES.

Type of Engine.	Name of Engine.	Performance at Normal Piston Speed and Normal Brake Mean Pressure.					Performance with Normal Piston Speed and 130 lbs./sq. in. B.M.E.P.			Performance with Normal B.M.E.P. and Piston Speed of 2,000 Ft./Min.			Performance with Piston Speed of 2,000 Ft./Min. and B.M.E.P. of 130 lbs./sq. in.		
		Weight per B.H.P. in Lbs.	R.P.M.	Piston Speed Feet/Min.	B.M.E.P. Lbs. per sq. ins.	B.H.P.	Weight Lbs./B.H.P.	R.P.M.	B.H.P.	Weight Lbs./B.H.P.	R.P.M.	B.H.P.	Weight Lbs./B.H.P.	R.P.M.	B.H.P.
Vertical Water Cooled	"Puma"	3.25	1400	1746	118.1	240	2.96	1400	264	2.84	1605	275	2.50	1605	312
Vee Water Cooled	300 H.P. Hispano Suiza	2.65	1800	1770	116.8	300	2.38	1800	334	2.34	2160	339	1.99	2160	400
Vee Water Cooled	Rolls Royce Eagle	3.37	1800	1950	124.0	350	3.21	1800	367	3.28	1847	359	3.13	1847	376
Vee Water Cooled	Liberty	2.69	1650	1925	118.0	405	2.44	1650	446	2.59	1715	420	2.34	1715	464
Arrow Water Cooled	Napier "Lion"	2.57	2000	1710	122.0	450	2.40	2000	480	2.19	2340	526	2.06	2340	561
Rotary Air Cooled	B.R.2.	2.10	1300	1536	95.2	238	1.53	1300	325	1.60	1690	310	1.17	1690	425
Radial Air Cooled	Cosmos "Jupiter"	1.75	1650	2060	109.5	400	1.47	1650	475	1.80	1600	388	1.52	1600	460

36%. It is obvious that within limits imposed by mechanical considerations, the thermal efficiency is increased by raising the compression ratio, but this is already in most cases as high as the fuel employed will permit.

In the constant volume cycle, the methods which offer a prospect of improving the thermal efficiency are :—

(1) Extending the expansion ratio keeping the maximum allowable compression ratio. This can be effected by :—
  (*a*) Mechanical devices for varying the stroke.
  (*b*) Compounding.
  (*c*) Allowing greater expansion than compression in the cylinder.

(2) Raising the compression ratio, made possible by the use of a fuel less liable to detonate.

(3) Supercharging.

(4) Stratified working by which losses due to cooling and variable specific heat and dissociation are reduced.

(5) Regeneration, *i.e.*, utilizing heat lost to the jacket and exhaust.

(6) Constant Pressure and dual cycles, etc.

(7) Direct injection.

Taking these methods in order, the first, (1*a*), can be carried out by varying the piston travel during successive strokes by the use of suitable mechanical devices. An early example of this is Atkinson's link motion (see Fig. 6, p. 696), and although it is stated that high mechanical efficiency was obtained in the early low speed gas engines, in which it was originally employed, the mechanism as used is hardly suited to aero engine practice, though it has the remarkable property of giving four strokes of different length per revolution for a four-stroke cycle, thus allowing high piston speed and low propeller speed.

Another device is an eccentric mounted on the crank-pin and rotated in suitable phase; this method can be readily applied to a radial engine. A variable stroke was obtained in one of the Clerget engines, and in the Zeitlin.

With regard to (1*b*), compounding, many attempts have been made to build a compound internal combustion engine, but so far with little success, even for heavy stationary engines; the difficulty has always been the loss of heat in transference of the working fluid to the low pressure cylinder. For aero work the large size of engine required to utilise the low pressures would make this method quite unsuitable. Better results are likely to be obtained by method (1*c*), allowing extended expansion in the same cylinder. This may be effected by late closing of the inlet valve during the compression stroke; this would, of course, involve the use of a lower compression ratio, unless the bearings can be raised by means of an eccentric mounting as a compensation.

Mr. Ricardo has suggested that this method should be employed to enable an engine, working with a very high compression at altitude, to be run at ground level at a lower compression without undue loss of efficiency.

The economy can be safely increased by raising the compression ratio above present ratios if special fuels are employed containing a higher proportion of toluene or other aromatic hydrocarbons. By using fuels containing suitable proportions of these compounds, the possible compression ratio at ground level may be raised from 4.85, the highest permissible with a light paraffin petrol, to 7.05, giving an increase in indicated thermal efficiency of from .311 to .373. Above this ratio we come to conditions in which, up to the present, only direct injection of fuel has overcome the pre-ignition and other difficulties. This is dealt with later. The addition of cooled exhaust products is another method which enables the compression ratio to be raised, or more difficult gases or fuels to be worked with. It was used by Clerk in 1902, added separately, and in Germany it was mixed with the gas previous to admission. The author was concerned with its use for admixture with coke oven gas in these early days. This gas has a large percentage of hydrogen, and is extremely prone to pre-ignition, etc.; it is quite readily used when mixed with cooled exhaust products at normal compressions. In considering the use of hydrogen for airship engines made available by the reduction of weight owing to the amount of fuel used, the use of cooled exhaust products as a diluent should not be lost sight of. Mr. Ricardo has proposed an ingenious form of altitude control by its use.

Supercharging, although it has hitherto been very little used, is undoubtedly likely to be employed again both for economy, increase of power, and for altitude correction; for high altitude work the alternative method

of forced induction will also undoubtedly come into use. In both, the mass of working fluid in the cylinder is increased. Pumps or rotary blowers may be employed or the required compressed air or cooled exhaust products or mixture of these for the extra charge may be obtained by utilising the exhaust pressure in the engine cylinders.

In a six cylinder-in-line engine this may be effected by using the exhaust pressure of one cylinder to blow air and cooled exhaust products into another cylinder at the phase of its cycle at which the extra charge is required. The thermodynamic economy in a supercharging engine is due to the lowering of the temperature of the working fluid while the mean pressure is kept high, so that the losses due to cooling and to the change of specific heat and dissociation are minimised.

STRATIFIED WORKING. The idea of stratified working is a very old one and was first raised by Otto and his supporters in an attempt to show that in the original Otto engines, also early two cycle engines, there existed at the moment of ignition a layer of inert gas in the neighbourhood of the piston. In the ordinary high speed four stroke or two-stroke petrol engine, there can be no doubt that owing to turbulence this is extremely difficult to obtain, for the cylinder at the moment of ignition contains a substantially homogeneous mixture. The use of a specially shaped cylinder head and proper control of the admission charge is one method of overcoming this and is used in one form by Ricardo. With delayed gas admission there is always a sufficiently rich mixture to ignite in the neighbourhood of the sparking plugs, while in the neighbourhood of the piston the mixture is ex-extremely weak or air alone. This makes possible the complete combustion of relatively weak mixtures, whereby the temperature in the engine cylinder can be very much reduced, so that, whereas in the ordinary cycle with fuel sufficient to burn the whole of the oxygen in the charge, the maximum temperature rises to approximately 2,500° C, means of stratification, the temperature, and with it the cooling and specific heat and dissociation losses, can be so much reduced that higher efficiencies can be obtained. In an engine with a compression ratio of 5 to 1 working with stratified charge at one-third full load a consumption of only 0.36 pint of benzol per indicated H.P. hour has been obtained. It will be seen that this method of working involves the use of large cylinders in proportion to the power obtained when running with maximum economy. Inversely it allows the power of an engine to be reduced with maximum economical working, a condition called for when the aeroplane is at flying elevation after leaving the ground. In another form used with two-cycle engines, extraordinarily good results were obtained by the author in 1913; these are given in Table 16. The engine was a large one and the speed slow; this allowed the stratification to be carried out with more than usual accuracy.

TABLE 16.

STRATIFIED CHARGING.

RESULTS OF EXPERIMENTS MADE ON A LARGE GAS ENGINE.

Two-Stroke-Cycle-Light Load-Slow Speeds.

Date.	Average B.T.U's per I.H.P. hour	Indicated Horse Power.	Mean Effective Pressure.	Revs. Per Minute.	Indicated Thermal Efficiency.
3-7-13	5620	83.5	30.4	87.0	45.2%
3-7-13	5800	83.2	31.4	87.0	43.8%
3-7-13	6020	81.7	29.9	87.0	42.2%
3-7-13	5930	87.0	31.0	89.0	42.8%
Average	5843	83.8	30.7	87.5	43.5%

Approximate Contents of Working Cylinder.
Volume of Cylinder = 8.49 cubic feet.
Volume of Mixture = 3.44 cubic feet.
Volume of Exhaust Products = 5.05 cubic feet.

REGENERATION. The great loss of heat to the jackets and by the exhaust has directed the attention of many designers to methods of conserving it. In stationary engines it has been proposed to employ the jacket water and exhaust heat to raise steam. In the Still engine the cylinder heat is utilised by using the generated steam on the other side of the internal combustion piston. There is no doubt that increased economy can be obtained in this way, but much experiment is required before this method can be adapted to aero engine work and the additional weight required will probably limit the use of the method to airships alone. Methods of using air as the heat transferring agency, to be added to the compressed cylinder air at the top of the cycle, have not been developed.

It is of interest to note that in the operation of exhaust driven turbine blowers for forced induction in high altitude engines, regeneration is to a certain extent employed owing to the conversion of a portion of the exhaust heat into kinetic energy in the turbine nozzles.

The constant pressure cycle has so far been very little employed, if at all, in aero engines. Owing to the higher compression which can be employed when air alone is compressed higher thermodynamic efficiencies can be obtained, but at the expense of considerably increased weight due to the much higher pressure. This cycle will probably find its most useful application in airship work where economy of consumption is of great importance and weight is of less account. In any case the type of engine most likely to be employed works probably more on the constant volume than on the constant pressure cycle. This type does not employ air to inject the fuel as in the Diesel.

Direct fuel injection is employed in all high compression engines, and as it can be used for other types as well, it has become of very great importance as a system for thorough investigation; and in addition to its advantages as regards performance, it materially reduces the risk of fire.

In the first type, in which the engine is of substantially the same strength and type as those in common use, the fuel is usually injected on the suction stroke or early in the compression stroke. With suction stroke injection remarkably high mean pressures have been obtained (over 130 lbs. per square inch) ; the economy so far is probably not up to that obtained with the usual carburettor ; later injection on the compression stroke tends to reduce the mean pressure as more penetration is involved, while the turbulence is decreasing. Finality has, however, by no means been reached, and considerably more experimenting is required ; the results so far obtained are of good augury. A further advantage of the system is that a common inlet and exhaust valve can be employed, allowing a large valve area and good volumetric efficiency for piston speeds up to 3,000 feet per minute and more ; also facilitating the cooling of the valves and cylinder head.

Direct injection was due to Akroyd-Stuart, and, therefore, he may be said to be the originator of all high compression engines, including the Diesel. The Blackstone engine uses two jets and works on the so-called "Dual" cycle.

In the higher compression types, including the Diesel, the compression may be up to 500 lbs. per square inch, and even over, with consequent very much increased engine weight. Unless this can be considerably reduced, the only field seems to be for airships. In the Vickers type, as used on submarines, where the compression is 380 to 400 lbs. per square inch, the remarkably low fuel consumption of .385 lbs. per B.H.P. hour has been obtained. What is also very valuable for long distance work, crude oil can be used with considerable saving in fuel cost. Although no airship engines are at work on this cycle in this country as yet, it is reported that they have been built in Germany.

Mechanical development will take place in raising output relatively and reducing weight per B.H.P. by overcoming the difficulties which impose limits to the speeds at which engines can now be run, which as previously mentioned, are reached in practically all types due to the bearing loadings and valve gear, etc.

Further, and most importantly by increasing the reliability by the gradual removal of all risks from over stressed parts or those still unknown.

With regard to the former, the difficulties of high speed increase with the thermodynamic and volumetric improvement, since the higher mean pressures involve increased strength and weight of connecting rods, big-ends, etc., with correspondingly increased inertia forces and bearing loadings.

Increase of compression ratio particularly approaches a limit at which any increase in thermodynamic efficiency involves such increased weights of moving parts that the advantage gained is more than balanced by the mechanical disadvantages involved. We may, with advantage, turn again to table 15. This table has been calculated for a common mean pressure of 130lb. per square inch and piston speed of 2,000 feet per minute. The increased speed difficulties are the greater, and it is important to compare their effects on different types. In the main, they refer to big-end bearings, main bearings, and valve gear. The difficulties of heavy bearing loading are most pronounced at the crankpin and become specially important in types with multiple big-ends, such as the radial ; but highest at the crankshaft in vertical, Vee and other types. The use of roller bearings, as in the R.A.F., Napier Lion, etc., has largely overcome these difficulties, though speeds and loads may possibly be further increased to a limited extent by the use of higher pressures for lubrication.

It is of interest to consider what are the actual limiting factors in engine speed.

(1.) Inertia forces and bearing loadings.
(2.) Provision of adequate valve area.
(3.) Acceleration forces in the valve gear.
(4.) Inertia of the connecting rod.
(5.) Rate of heat flow as affecting jacket walls, piston, valves and sparking plugs.
(6.) Ignition gear.

It is not proposed to discuss all these factors in relation to the limiting speed, the primary object being to draw attention to the limitation imposed by the bearing loadings ; it is, however, of interest to note that with the exception of item (6.) and, to a certain extent, item (2.), increased speed seems to point to the necessity of using small cylinders. This is especially the case as regards the inertia forces since the masses concerned are invariably machined all over and their weight varies therefore as the cube of their dimensions.

To direct attention to the importance of the big-end and its limiting effect on speed, the following approximate figures have been kindly worked out at the request of the Lecturer, by Mr. H A. Hetherington. They reveal the state of affairs very clearly ; it will be seen that the simple six can be run very much faster than the single-plane radial, a point hardly sufficiently realised when comparing types. Further, if other considerations did not in turn become limiting features, it is indicated that there is less difference between weights of various types than is usually supposed.

In examining this important limitation let us assume four engines, each of 1,200 cu. ins. capacity, stroke/bore ratio = 1.17 : 1 and running at a piston speed (v) of 2,000 ft. per min.

The dimensions of the engines will be assumed to be as follows :—

	Bore	Stroke
(*a*) Six cyl. vertical ..	6.00″	7.00″
(*b*) Twelve cyl. Vee ..	4.78″	5.60″
(*c*) Twelve cyl. Fan ..	4.78″	5.60″
(*d*) Nine cyl. Radial ..	5.25″	6.14″

The equivalent revolution speeds corresponding to a piston speed (v) of 2,000 ft./min. will be given by

$$n = 12000/s$$

which gives us

(*a*) = 1715 r.p.m.
(*b*) = 2140 r.p.m.
(*c*) = 2140 r.p.m.
(*d*) = 1960 r.p.m.

The rotating weight acting on the big-end bearing will be assumed to be equal to

$$Wt = 0.18 \times A \times \text{Constant}$$

A being the area of one piston in sq. ins., and the constant varying according to the number of pistons coupled to one crankpin.

With the above assumptions we arrive at the following values for the rotating weights (*wt.*) acting on the big-end bearing.

(*a*) $0.18 \times 28.4 \times 1 = 5.1$ lbs.
(*b*) $0.18 \times 18.0 \times 1.8 = 5.82$ lbs.
(*c*) $0.18 \times 18.0 \times 2.3 = 7.45$ lbs.
(*d*) $0.18 \times 21.7 \times 4.2 = 16.4$ lbs.

The centrifugal pressure (cp) due to these rotating masses is given by the formula :—

$$cp = 0.000142 \times w \times n^2 \times s$$

which gives us the following values for the four types of engines under consideration :—

(*a*) 1,490 lbs.
(*b*) 2,120 „
(*c*) 2,720 „
(*d*) 5,480 „

In order to get some idea of the actual loading on the big-end bearing, due to this pressure, we must further assume some dimensions for the crankpin which agree reasonably well with average modern practice. The dimensions which have been assumed are tabulated below for the four types of engines.

	Ins.		Ins.	
	(*a*)	(*b*)	(*c*)	(*d*)
Bore of cyl.	6.0	4.78	4.78	5.25
Diam. of crankpin	2.52	2.15	2.20	2.62
Ratio $\frac{\text{Diam. crankpin}}{\text{Bore of cyl.}}$ ..	0.42	0.45	0.46	0.50
Effective length of big-end bearing (ins.)	2.9	2.3	2.5	3.1
Projected area big-end bearing (sq. ins.)	7.5	4.95	5.5	8.12

With the above dimensions the loading (*cl.*) on the big-end bearing, due solely to the rotating weights, will be as follows :—

(*a*) 200 lbs. sq. in.
(*b*) 433 ,, ,, ,,
(*c*) 495 ,, ,, ,,
(*d*) 632 ,, ,, ,,

The rubbing velocity (*rv*) is given by the formula :—

$rv = 0.00436 \times d \times n$ (ft. sec.).

d being the diameter of the crankpin (ins.).

The load factor (*lf*) for the centrifugal loading only, will be equal to the centrifugal loading (lbs. sq. in.) multiplied by the rubbing velocity (ft. sec.).

$lf = cl \times rv$ (lbs. ft. sec.).*

With the above assumptions we get the following values for the load factor :—

(*a*) $200 \times 18.85 =$ 3770 lbs. ft. sec.
(*b*) $433 \times 20.1 =$ 8700 ,, ,, ,,
(*c*) $495 \times 20.5 =$ 10150 ,, ,, ,,
(*d*) $632 \times 22.4 =$ 14150 ,, ,, ,,

In considering these figures a comparison can only be usefully made between engines (*a*), (*b*) and (*c*) as in these three types it is customary to use the same type of big-end bearing (*i.e.*, white metal on steel), whereas in the case of radial engines the big-end bearing is usually fitted with ball or roller bearings. On the other hand the use of ball or roller bearings very considerably increases the rotating weight so that full advantage cannot be taken of the fact that they can be more heavily loaded with safety than a plain bearing. It would appear that a hopeful solution for the big-end bearing of a radial engine would lie with a composite plain bearing, consisting of a number of floating bushes with adjacent rubbing surfaces of case-hardened steel and bronze.

Referring again to the four types of engines under consideration, the following table shows the variation in r.p.m. piston speed, centrifugal loading and load factor under various conditions :—

* The Michell principle does not follow this rule.

Permissible Increase in Engine Speed for a Constant Centrifugal Loading on Big-End Bearing.

Type of engine ..	(*a*)	(*b*)	(*c*)	(*d*)
r.p.m. for piston speed = 2,000 ft./min.	1750	2140	2140	1960
Centrifugal loading on big-end bearing (lbs. sq. in.)	200	433	495	632
Permissible increase in engine speed for centrifugal loading = 632 lbs. sq. in.	78%	21%	13%	0

Permissible Increase in Engine Speed for a Constant Load Factor—(centrifugal loading only).

Type of engine ..	(*a*) ..	(*b*)	(*c*)	(*d*)
r.p.m. for piston speed = 2,000 ft./min.	1715	2140	2140	1960
Load factor—(lbs. ft. sec.)	3770	8700	10150	14150
Permissible increase in engine speed for load factor = 14150 lbs. ft. sec. ..	55.5%	18%	12%	0

Values of centrifugal loading and load factor for constant speed = 2,000 r.p.m. This condition is that of constant power if the value of p is assumed to be the same for all engines.

Type of engine ..	(*a*)	(*b*)	(*c*)	(*d*)
Centrifugal loading on big-end bearing (lbs. sq. in.)	272	378	432	660
Load factor (lbs. ft. sec.)	5980	7120	8300	15100

By far the most heavily loaded bearing in six, eight or twelve cylinder engines or, in fact, in any arrangement other than the radial type, is the centre crankshaft journal bearing. The loading on this bearing can, of course, be reduced by the use of balance weights, but this method of dealing with the trouble entails other disadvantages apart from the considerable increase in the weight of the engine.

In the author's opinion, as just stated, however, the loading on this bearing can be dealt with by the employment of roller bearings, or, perhaps, special sleeve types, or Michell bearings

It will be seen that the centrifugal load varies as the square of the speed, whereas the value of the load factor varies as the cube, so that any reduction in the rubbing velocity by the use of floating bushes, for example, would be of considerable assistance quite apart from their tendency to reduce local wear on the crankpin.

In addition to the loading imposed solely by the rotating masses, the big-end bearing is also subjected to loading due to the fluid and inertia pressures. The mean fluid pressure is approximately constant and for the purpose of comparison may be taken as being equal to 50 lbs. sq. in. multiplied by the total area of the pistons attached to the crankpin, multiplied by a constant depending on the grouping of the cylinders.

The mean average loading due to inertia will vary in the different types of engines according to the arrangement of the cylinders.

With regard to the permissible value of the load factor for the big-end bearing, for continuous running, it is of interest to note that Güldner in "Design and Construction of Internal Combustion Engines" gives 1,650 lbs. ft. sec. as a maximum value "*where very careful construction and perfect lubrication is assured.*" Güldner is, however, only referring to relatively large slow speed engines, where rather different conditions prevail as regards lubrication and to engines which are required to run continuously for very long periods without overhaul.

In view of Güldner's figure, quoted above, it is of interest to note the very high values of the load factors, attained in several different types of engines which have proved successful in service.

TABLE 17.

BEARING LOADINGS AND LOAD FACTORS FOR BIG END AND CENTRE JOURNAL BEARINGS, (SIX CYLINDER VERTICAL ENGINES.)

Engine.	R.P.M.	Piston speed (Ft./Sec.)	Big End Bearing. Mean average loading (lbs.sq.in.)	Big End Bearing. Load factor (lbs.ft.sec.)	Centre Journal Bearing. Mean average loading (lbs.sq.in.)	Centre Journal Bearing. Load Factor (lbs.ft.sec.)
150 H.P. Ricardo Tank Engine	1200	1500	421	6330	400	6020
230 H.P. Benz	1400	1745	421	6070	805	12000
260 H.P. Mercedes ..	1400	1654	440	6780	595	9040
300 H.P. Maybach ..	1400	1654	580	9200	753	11920

NOTE.—The load factor for centre journal bearing in Benz and Maybach engines is unusually high for German practice, and it is interesting to note that these two engines are the only German engines fitted with ventilating arrangements to the crankcase, and in the case of the Benz engine, a form of oil cooler is incorporated in the sump.

The following figures have recently been published by the U.S. Government regarding the 12-cylinder Vee type Liberty aircraft engine. The figures given are for the total loading, fluid, inertia and centrifugal.

LIBERTY 12 CYL. VEE AIRCRAFT ENGINE.

Bearing loadings and load factors, 1,700 r.p.m.

Big-end Bearing.

Centrifugal loading only	lbs. sq. in.	366
Total average loading	lbs. sq. in.	642
Rubbing velocity	ft/sec.	17.7
Load factor (Total av. loading)	lbs. ft. sec.	13,500

Centre journal bearing.

Total average loading	lbs. sq. in.	1,265
Rubbing velocity	ft./sec.	19.5
Load factor	lbs. ft. sec.	24,670

Intermediate journal bearings.

Total average loading	lbs. sq. in.	700
Rubbing velocity	ft./sec.	19.5
Load factor	lbs. ft. sec.	13,650

End journal bearing.

Total average loading	lbs. sq. in.	610
Rubbing velocity	ft./sec.	19.5
Load factor	lbs. ft. sec.	11,900

From the figures given for the Liberty engine, it would appear that it is actually possible to employ a load factor, as high as 24,000 lbs. ft. sec. continuously, provided that very ample lubrication is assured, together with an efficient system of oil cooling, but there is little doubt that with such a high value, wear will take place, and in order to reduce such wear to a minimum, it would be necessary to employ very hard steels for the crankshaft. It should also be pointed out that in such high speed engines the wear on the crankpin is very local.

It is interesting to note that the specific bearing pressure depends solely on the projected area of the bearing, whereas the load factor is influenced only by the length of the bearing.

For example, take the case of the centre journal bearing of the Liberty aircraft engine when running at 1,700 r.p.m.

Diameter of journal	= 2.625″
Effective length journal bearing	= 1.75″
Projected area	= 4.59 sq. ins.
Total average loading	= 5,810 lbs.
Mean average loading (5810/4.59)	= 1,265 lbs. sq. in.
Rubbing velocity	= 19.5 ft. sec.
Load factor (1,265 × 19.5)	= 24,700 lbs. ft. sec.

Assume diameter of the crankshaft to be increased from 2.625″ to 3.00″ :

Projected area of bearing	= 5.25 sq. in.
Mean average loading (5810/5.25)	= 1,110 lbs. sq. in.
Rubbing velocity	= 22.3 ft./sec.
Load factor (1,110 × 22.3)	= 24,700 lbs. ft. sec.

i.e., any increase in shaft diameter is neutralized by the increase in the rubbing velocity.

Taking now the diameter of the crankshaft as in the first case, *i.e.*, 2.625″ and lengthening the bearing from 1.75″ to 2.25″ :

Projected area of bearing (2.625 × 2.25) .	= 5.9 sq. ins.
Mean average loading (5810/5.9)	= 985 lbs. sq. in.
Rubbing velocity	= 19.5 ft/sec.
Load factor (985 × 19.5)	= 19,200 lbs. ft. sec.

Taking the limit type engine, the straight six, with an allowable increase of speed of 50%, the weight comes out approximately the same as the radial.

The loading factor of the big-end in the radial may be reduced either by giving the cylinders an opposite rotation to the crankshaft, as in the differential, thus making possible an increase of speed of about 20%, or by the adoption of special bearings, or other means not yet known.

New mechanical arrangements of cylinders, such as that employed in the swashplate type, may give advantages in this respect, though they will undoubtedly set up many other mechanical problems that will take time to solve satisfactorily.

With regard to valve gear, high volumetric efficiency involves the use of ample valve area, and large valves give rise to trouble in their operation at high speeds. In stationary vertical and Vee type engines the weights of reciprocating parts of the valve gear may be reduced by the use of overhead camshafts operating directly on the ends of the valve spindle as in the Hispano-Suiza design.

In radial engines the valves must be operated by cams at a considerable distance from the cylinder heads. It is obvious that for the higher speeds the weight must be still further cut down; the shock of reversal and infinite acceleration due to over clearance are further difficulties; unistressed gears, *i.e.*, always stressed in one direction, and the use of centrifugal force reduce weight and obviate the use of heavy springs. If the cylinders are made to rotate at a comparatively low speed, a light tension valve gear stressed always in one direction by centrifugal force may be employed and with practically no valve springs.

As an example, let us take the two cases of an engine 6.00″ bore and 7.00″ stroke running at 1500 r.p.m. and 2500 r.p.m. We will assume that we wish to employ a mean gas velocity of 150 ft. per sec. in both cases.

Let A = Area piston, sq. ins.
K = Piston speed, ft. sec.
d = Diam. valve port, ins.
h = Lift of valve, ins.

We will further assume that the area through the valve (a) is equal to

$a = 3.14\ dh$ (sq. ins.)

Then for the required gas velocity

$a = AK/150$ (sq. ins.)

Solving for the two engine speeds, we have

(1.) $a = 28.3 \times 29.2/150$
$= 5.5$ sq. ins. at 1500 r.p.m.

(2.) $a = 28.3 \times 48.6/150$
$= 9.16$ sq. ins. at 2500 r.p.m.

This means that for 1500 r.p.m. we shall require four valves 1.87″ diam. and for 2500 r.p.m. four valves 2.42″ diameter.

The relative weights of the valves will be as

$$1.87^3 : 2.42^3$$
$$= 6.55 : 14.2$$
$$= 1 : 2.16$$

and the required lift (h)

$$h = 0.4675'' : 0.605''$$
$$= 1 : 1.29$$

The difficulty of operating the valve gear of an engine of this size at such a high speed is at once apparent from the above figures.

Apart from other limiting factors it is also obvious that a limit will eventually be reached when the revolution speed is such that the connecting rod will fail in bending due to its own inertia.

With regard to the rate of heat flow, the advantage undoubtedly lies with the small cylinder both as regards the uncooled parts of the engine, such as pistons, valves, plugs, etc., and also in the relative size of radiator required.

Instead of poppet valves involving rapid reversal of direction of motion, rotating valves constantly moving in one direction may be employed, for example, sleeve valves. This type, with an additional reciprocating motion, was used in the Argyll engine which competed in the aeroplane engine trials in 1914, but very little has been done since, and knowledge as to its probable behaviour for aero work is lacking.

Considerable experiment would probably be required to attain successful results. The fundamental difficulty seems to be that of cooling, particularly transferring the heat through the oil film between the sleeve and the cylinder.

Cylinders. In the consideration as to the trend of cylinder design in the direction of either water or air-cooling, the tests carried out at Farnborough will have a very complete bearing.

This research is of the greatest value in connection with the development of the radial engine, both with fixed and rotating cylinders, and has definitely established that, with suitable materials and design, mean effective pressures can be obtained in air-cooled engines nearly as high as those which have been obtained with water-cooling, and with consumptions reduced to a figure approaching the best hitherto obtained in water-cooled engines.

Experience with the R.A.F. 4 D cylinder, and modified cylinders, led to the design of the 21 T.D. cylinder, and later the smaller 22 T.W. cylinder. Both have aluminium heads cast on to steel barrels. These cylinders were very successful, as will be seen from the particulars given in Table 18, which gives their performance arranged as single cylinder units.

TABLE 18.

RESULTS OF TESTS ON AIR COOLED CYLINDERS.

Type of Cylinder.		Dragonfly Mk. II.		R.A.E. 21 T.D.		R.A.E. 22 T.W.		R.A.E. 22 T.W.	
Bore of Cylinder	Inches.	5.5	5.5	5.5	5.5	4.5	4.5	4.5	4.5
Stroke of Piston	Inches.	6.5	6.5	6.5	6.5	6	6	6	6
Revs. per Minute	R.P.M.	1450	1650	1450	1650	1800	2000	1800	2000
Brake Horse Power	B.H.P.	31.4	34.0	36.0	39.7	29.0	31.08	28.9	32.35
Brake Mean Pressure	B.M.E.P.	110.2	105.1	127.0	123.0	133.9	128.8	133.6	134.0
Fuel Consumption	Lbs. B.H.P. Hr.	0.722	0.793	0.518	0.537	0.430	0.535	0.468	0.477
Weight of Cylinder	Lbs.	24.25	24.25	26.88	26.88	18.4	18.4	18.4	18.4
Compression Ratio	R.	4.6	4.6	5.0	5.0	5.1	5.1	5.5	5.5

The results of these experiments which were carried out in the earlier stages by Dr. A. H. Gibson and later by Major G. H. Norman, are of the greatest value. Norman's conclusions as to the present position of development of the air-cooled engine without taking account of future experiments, are stated as follows. That an air-cooled engine can be built:—

(1) Having a B.M.E.P. of 120 lbs. per sq. in. on the complete engine.
(2) Of weight not more than 2 lbs. per B.H.P.
(3) Capable of standing full load under the same conditions as a water-cooled engine.
(4) Having a fuel consumption not exceeding 0.55 lbs. per B.H.P. hour.

Two-Cycle Engines. Though the two-cycle engine has always had a great attraction, particularly to the non-technical, it has never made much progress for aero engine work. No doubt the fact that it had twice the number of working strokes of the engine ordinarily used, the four-stroke, was the reason of this. It was further supposed to be simpler. In these comparisons the charging pumps with their valves were somewhat overlooked, but the real difficulty and the one to keep the engine out of use was its low fuel economy, and the difficulties of getting rid of the extra heat.

The charging of the working cylinder with mixture was the main cause. Some of it escaped, and some inert gas remained in the cylinder to heat up the rest, reduce its efficiency and render it more liable to pre-ignition. Proper scavenging at high speed is extremely difficult.

The advent of the direct injection method has greatly changed this situation, and there now seem much greater possibilities of the two-cycle coming into use for aero work, and probably land transport as well.

The direct injection method of Akroyd Stuart of supplying fuel to the engine cylinder has realised its present efficiency through its development in the Diesel and high compression oil engines, and it is dealt with elsewhere. By its use the engine cylinder can now be scavenged by air alone, the fuel being injected direct in the constant volume cycle, just as the ports are closing or immediately after. Thus the old fundamental trouble of escape of mixture is overcome. At the present time the two-cycle principle is in use in Diesel and high compression engines.

For aero work when large port area is essential, piston type valves are most likely to be employed. This type of valve with its regular action and low acceleration stresses allows of high speeds. Thus we may get a two-cycle engine running at higher speeds than a poppet valve four-cycle with safety.

With regard to the increase of power, it would not be safe to count on more than 50% over that of a four-cycle of equivalent cylinder capacity.

This means that 50% of additional heat has to be dissipated in the same time. Hence, in the first development water-cooling is likely to be adopted, though ultimately it may be possible to use air.

The scavenging and charging of the cylinder may be carried out by turbo-blowers worked from the exhaust pressure as in the forced induction trials on the four-cycle.

Economy of fuel will not be so good as with the four-cycle in the first instance, still 0.6 lbs. should be achieved, and with the reduction in weight that will be possible, should, for flights under three hours, make the type quite suitable. The loadings on the big-end will be, in effect, worse, hence some compensating device may be necessary if the type chosen is the radial.

For civil aviation at present, only well-known and tried types are likely to be employed, and the choice of practicable engines at the moment appears to be between the simple six-cylinder in line, multicylinder Vee and double Vee engines, though the first must reduce its weight ratio by raising the rotational speed, when the difficult problem of gear reduction to allow efficient propeller speed will come in. In the author's view, these are the types at the moment whose reliability renders them suitable for commercial work; civil aviation will ultimately depend for success on the development in performance and reliability of lighter types which have been discussed.

With regard to metallurgical development, the possibilities of improvement are mainly in change in the materials of construction.

During the war, higher and higher value steels were brought out by the metallurgists allowing stresses to be put up and weight of parts cut down. Also the use of aluminium alloys reduced the weight of cast parts, as the pistons, crank cases, etc., and greatly improved the conductivity of heat-carrying parts.

Thus the advance went on parallel lines, the higher value steel allowed higher speeds, while the greater rate of heat flow was met by the use of aluminium.

There is no doubt that progress will continue in these ways from the further improvement of the materials. Possibly there may be more radical changes, the

substitution of a metal of low specific gravity for steel.

The table of specific gravities already shown is interesting. The German alloy electron has a specific gravity of 1.8, but is not included in the Table.

For airship service engines are required to run continuously for long periods, and for these long runs weight of fuel and oil becomes of considerable importance as compared with engine weight. Further, since non-stop runs of 100 hours or more must be contemplated, the reliability of the motor must be of a high order.

Accessibility is also deemed essential to enable examination and adjustment and replacement of parts in flight and to enable minor repairs to be made.

At present, the engines which have been employed are very similar to the ordinary vertical and Vee type aeroplane engines.

There is undoubtedly room for considerable advance in engines for airships without departing from the four-stroke cycle and by adopting modifications of the cycle by which increased economy can be obtained. The method of stratification described would appear to be particularly suitable for employment, owing to its very high economy, particularly in cases, common in airship work, where only a part of the full power is required for long periods. The great advantage of economy will be apparent from an example; taking an engine of 300 H.P., with weight 1,500 lbs. and consumption 0.5 lbs. per B.H.P. hour. For a 100 hours' run the fuel required would be 15,000 lbs., or ten times the engine weight. A reduction of fuel consumption to 0.45 lbs. would reduce the weight of fuel by 1,500 lbs., so that double the engine weight would be allowed. Consumption considerably lower than this can be attained, namely, in the region of 0.4 lbs. per B.H.P. hour.

In the high compression direct injection method with a fuel consumption of 0.4 lbs. per B.H.P. hour the consumption would be 3,000 lbs. less. This type will, however, require to be made lighter, possibly of the opposed piston form, before it can compete with the most economical forms of the constant volume engine for aero work.

Many proposals have been made for the use of steam turbines for aero work, but steam turbine efficiencies can by no means compete with those obtainable by the internal combustion method, as indicated in an earlier lecture, particularly in units of the low power output required.

The feature of being able to use crude oil is a valuable one, but can be secured by the use of high compression internal combustion engines with greatly reduced fuel consumption.

There are undoubtedly future possibilities in the application of the internal combustion turbine to aero work, but the gas turbine for any purpose is in a very immature stage of development, and consideration of its relative advantages would seem to be premature.

In view of the attention which it is hoped will be directed to commercial aviation, it may be of interest to consider the effect of the weight of the engine on the carrying capacity of a given machine. It will, of course, be obvious that for short flights where little fuel has to be carried and the weight of fuel is small relatively to the weight of the engine, the use of an engine of low weight per horse-power is of fundamental importance, and economy is comparatively unimportant. It is also obvious that for very long flights where the weight

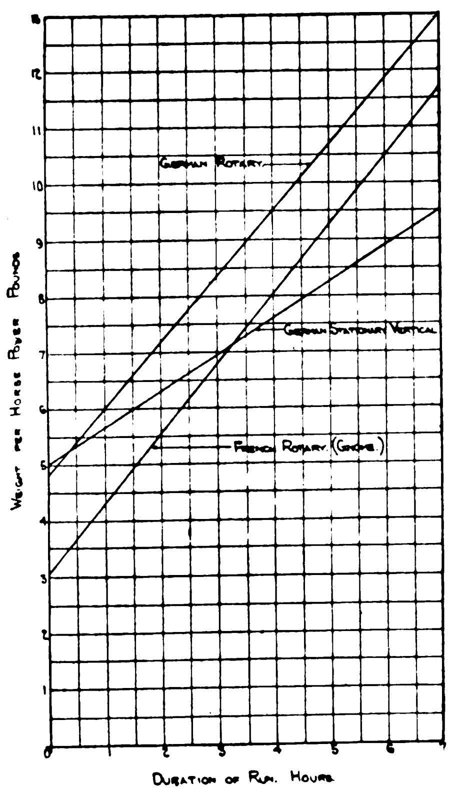

Fig. 19.

of fuel to be carried becomes large relatively to the engine weight, low weight of engine is of less importance than economy of fuel and oil consumption. This is very clearly shewn by the curves, figure 19, which in the abscissae represent hours run and the ordinates weight of engine and fuel per horse power in lbs. The performances of a number of different engines are shewn, and the heavier early German engines are compared with the light Gnome engine. It will be seen that for runs of anything over three hours, the average German engine has the advantage, while below three hours run the light engine gives an undoubted saving in weight and consequent greater carrying capacity, and would, therefore, seem a better commercial proposition. As an example of the commercial importance of a low weight engine, we may consider a flight of 2½ hours, such as that required in the Paris service, which may fairly be taken as typical of the length of stage which will be required in commercial aviation. This length of flight would seem to be the most usual in charge of a single pilot.

Assuming power units of 500 B.H.P. with weights per B.H.P. 1.5, 2.5, and 3.5 lbs., with fuel and oil consumptions of 0.6, 0.5, and 0.45 lbs. respectively, the weight of power unit and fuel in the three cases would be :—

TABLE 19.

LONDON-PARIS SERVICE.

Type of Engine.		a	b	c
Brake Horse Power of Engine	B.H.P.	500	500	500
Weight per B.H.P.	Lbs.	1.5	2.5	3.5
Fuel and Oil Consumption per B.H.P. Hour	Lbs.	0.6	0.5	0.45
Weight of Power Unit, Fuel, and Oil for 2½ hr.	Lbs.	1500	1875	2312
Weight of 5 Passengers at 160lbs. each	Lbs.	800	800	800
Weight of Power Unit, 5 Passengers, Fuel and Oil for 2½ hours	Lbs.	2300	2675	3112
Saving of Weight based on Engine "C"	Lbs.	812	437	Nil.
Number of Passengers Equivalent to Saving of Weight		5	3	Nil.
Total Number of Passengers that could be carried		10	8	5
Total Earnings at £10 10s. per Passenger for 50 Flights		£5250	£4200	£2625
Running Time Allowed between Overhauls	Hours	50	100	150
Total Running Time for 50 Flights	Hours	125	125	125
Number of Overhauls		2.5	1.25	0.83
Cost of Upkeep and Replacements assuming £50 per Overhaul		£125 0 0	£62 10 0	£41 13 0
Cost of Fuel at 4/- per Gallon for 50 Flights		£1000 0 0	£833 6 8	£750 0 0
Total Cost for 50 Flights		£1125 0 0	£895 16 8	£791 13 0
Nett Earnings for 50 Flight		£4125 0 0	£3304 3 4	£1833 7 0

(*a*) 1500 lbs. (*b*) 1,875 lbs. (*c*) 2,312 lbs. With the lightest engine (*a*), therefore, the saving in weight would be 812 lbs. equivalent to five passengers, and with the medium weight engine, 437 pounds, equivalent to three passengers.

The earnings of fifty London-Paris flights at ten guineas per passenger are given in the following Table.

It will be seen from Table 19, that the total net earnings in the case of the lightest engine will be £4,125, in the case of the medium engine £3,304 3s. 4d., and in the case of the heavy engine £1,833 7s.

The earnings for a given carrying capacity, it will be noted, are very large in proportion to any fuel costs likely to be incurred even in the most wasteful of engines as regards consumption.

In this calculation, no account has been taken of the initial cost, as this is independent of type, and with greater development may well be in favour of the lighter engine. The provision and maintenance of a given number of engines in working order is allowed for in the renewals and replacement item. These figures very clearly show that for flights, such as those required on the London-

TABLE 20.

AVERAGE NUMBER OF HOURS RUN BETWEEN OVERHAULS.

Make of Engine.	Horse. Power.	Total number of Engines.	Total number of hours run.	Average of hours run.
Le Rhone	110	100	5407.4	54.1
Clerget	140	100	1507.4	15.1
B.R.1.	150	25	734.7	29.5
Beardmore	160	35	1685.0	48.1
Hispano-Suiza (Delaunay Belleville)	200	25	1037.5	41.5
Hispano-Suiza (Peugeot)	200	100	3864.6	38.6
Hispano-Suiza (Mayen)	200	84	2492.2	29.7
Hispano-Suiza, English (Viper) ..	200	100	5466.2	54.6
Hispano-Suiza, English	200	95	3449.5	37.0
Rolls Royce (Early Engines) ..	275	100	6135.3	61.3
Rolls Royce (Later Engines) ..	275	50	5161.6	103.2

TABLE 21.

RELATIVE VALUE OF MAN HOURS REQUIRED COMPLETELY TO OVERHAUL AN ENGINE.

Horse Power.	Make of Engine.	Type.	Rel. Value Man-Hours.
120	Beardmore	Vertical	1.5
160	Beardmore	Vertical	1.5
90	R.A.F.1A	Vee	1.0
140	R.A.F.4A	Vee	1.5
200	Hispano "Viper" ..	Vee	2.0
265	Rolls Royce "Falcon" ..	Vee	3.0
350	Rolls Royce "Eagle" ..	Vee	3.0
400	Liberty	Vee	2.0
80	Le Rhone..	Rotary	0.5
110	Le Rhone	Rotary	0.5
100	Mono Gnome	Rotary	1.0
130	Clerget	Rotary	1.0
200	B.R.2	Rotary	1.0

Paris services, light weight per H.P. is of the first importance.

It has been assumed that the consumption in the light weight engine is very much greater than that in the heavier engine. With further development of the lighter types this is by no means necessary, and improvements in fuel consumption would obviously increase the balance in favour of light weight.

The above Tables, numbers 20 and 21, have been compiled by Lieut.-Col. L. F. R. Fell, D.S.O., from the records of the engine repair shops of the Royal Air Force in France, and are included on account of their great interest. Table 20 is a summary shewing the average number of hours run between overhauls of various engines under active service conditions. It is of particular interest in that the figures for the 200 horse-power Hispano-Suiza indicate very clearly the effect of manufacture on the same type of engine. In the case of the Rolls Royce, two independent batches and averages have been taken. With regard to Table 21, shewing the relative value of the man-hours required completely to overhaul, the short period of time necessary for the simple type radial as seen in the case of the Le Rhone engines should be noted.

OBITUARY.

Henry Morris Upcher, D.L., J.P.—Mr. Henry Morris Upcher, of Sheringham Hall, Norfolk, who died lately in his eighty-second year, joined the Royal Society of Arts in 1900. The son of Mr. Henry Ramey Upcher, he was educated at Harrow and Trinity College, Cambridge. After leaving Harrow, and before going to the University, he accompanied Canon Tristram on the first of his notable journeys in Palestine. Mr. Upcher was one of the ornithologists of the party, and his quick straight eye earned for him, from the Arabs, the title of "The Father of Two Eyers." He was amongst the earliest members of the British Ornithologists' Union, a Past-President of the Norfolk and Norwich Naturalists' Society, and formed a fine collection of birds. He did much to encourage the development of Sheringham as a seaside resort, and rendered other valuable public services to the locality. He was Lord of the Manor and, in 1889-90, High Sheriff of his county. During the War, in spite of his age, he performed the duties of Chief Special Constable for the Sheringham District.

MANUFACTURE OF FLAX STRAW WASTE IN ARGENTINA.

Although many attempts have been made to utilise the fibre plants, such as reeds, rushes, and grasses, which abound in Argentina, only a few have been successful. Not more than one Argentine company, reports the U.S. Trade Commissioner in Argentina, is at present producing fibre goods on a commercial scale. The raw material used is flax straw and the finished product is waste, which is baled and sold to European firms, who convert it into various materials for which it is adapted. This company has been experimenting since 1911 with different processes for extracting the gums from the straw and cleaning the fibres. It now uses a patented retting system which operates on a thermo-chemico-mechanical basis and delivers the straw ready for the drying ovens in less than half-an-hour after it is started through the first machine. The product of this new process is reported to be equal or even superior in colour elasticity, length of fibre, and resistance to fibres retted by the old methods, which required many days' time. The Argentine Minister of Agriculture appointed a technical commission to report on all phases of this industry and the findings were published by the Director of Statistics and Rural Economy.

The above mentioned company has its plant at Arrecifes, about 160 kilometres (1 kilo=0.621 mile) from Buenos Aires on the Central Argentine Railway. The present capacity of the plant is 3 to 5 tons of waste per day, obtained from 25 tons of straw. The woody parts are stripped from the fibres in one of the machines and sent to the boiler rooms, where they furnish all the heat needed for the retting bath and for power and light in and about the factory buildings. The gums, resins, and other by-products are not recovered at present, but it is expected to utilise them when the full equipment is installed The foreman and one of the helpers were brought from Europe to teach native labour how to handle the flax in the different stages throughout the process.

One defect which has yet to be overcome is the shortness of the fibre. No attention has been paid hitherto by the cultivators of flax or linseed to selecting plants which would produce long fibres, nor has care been taken in harvesting to leave as much of the stalk standing as possible. Up to the present care has been taken only to insure good seed. In order to encourage fibre as well as seed production, the company has planted a small area with special seeds to demonstrate the difference between the two classes of flax, and it has imported machinery for reaping the linseed by means of a comb-shaped collector, which takes off the seeds without touching the stalks. The flax is then cut close to the ground and the entire length of fibre is made available with practically no loss.

Approximately 5,400,000 tons of linseed straw are available in Argentina; there are about 1,800,000 hectares (1 hectare = 2.471 acres) under cultivation, and each hectare yields on an average 3 tons of straw. Except for the small amount consumed by the fibre company, this straw is burnt. The company intends to erect several plants in the centre of the flax districts in order to avoid transporting the straw long distances, which adds greatly to the cost.

It is estimated that if all the straw available were to be utilised there would be sufficient to make 1,000,000 tons of waste and fibre. With this raw material it would be possible to manufacture all the 160,000,000 grain bags required annually, as well as the thread, cord, and canvas consumed locally, and still leave a large surplus for export.

THE FUR INDUSTRY IN SIBERIA BEFORE THE WAR.

There are large areas in Siberia admirably fitted for the development of the fur industry. Immeasurable forests, inaccessible mountains, and sparse population provide the animals with the best conditions for propagation. The most favourable locality, a kind of natural zoological park, is the Pri-Amur region. The following particulars regarding the fur industry in Siberia before the War are from a memorandum prepared by the Russian Division of the United States Bureau of Foreign and Domestic Commerce.

Formerly the sable was very common in the forests of Siberia from the Ural Mountains to Behring Sea and from the southern boundaries of Siberia to 68° of north latitude. Nowadays the sable is found only in the most remote and untravelled areas; in Western Siberia in Pelym, north of the River Tavda; along the Rivers Konda and Turgas, Government of Tobolsk; Berezovsk County, along the River Sosva; Sargut County, Government of Tobolsk; in Tomsk Government; in the Narym region, Kuznetsk and Biisk Counties (in their mountain and virgin forest portions); in the Yenisei Government; in the Turukhansk and Usinsk regions and in Priangara; in the Irkutsk Government, along the Rivers Kirenga and Ilim; in Trans-Baikalia, along the Rivers Barguzin, Tchikoi and Nertcha; in Irkutsk region, along the Rivers Vitim and Mui; in the Kolym region; in the Pri-Amur region, Amur, Ussuri, and Udsk Counties; on Sakhalin Island and in the Kamtchatka Peninsula.

As a rule, the quality of the fur skins from Siberian animals improves in regions from west to east, the colour becoming darker and the fur softer. The West Siberian sables, therefore, are of the lower quality in both colour and thickness. The best of them are from Berezovsk and Narymsk, and the lowest grades are from Pelymsk, Tobolsk, and Tarsk. Those from Biisk and Kuznetsk are of medium quality. Turukhansk sables have dark, thick fur, which is coarse and without lustre. The Vitimsk, Barguzinsk, and Muisk sables, with dark, thick and soft fur, having silver ends, are nearly extinct and flourish only in very cold and dry localities far from the sea. The climate of Kamtchatka is damp, and for this reason the sable skins there are of lower quality. In the Pri-Amur region the best sables come from Zeisk, Amgunsk, and Amursk. The poorest sables are those from Sakhalin Island.

Only the most experienced experts are able to estimate correctly the true value of a sable. The maximum quantity of skins was shipped from the Maritime Amur region, the largest fur markets being Khabarovsk, Vladivostok, Nikolsk, Ussuriisk, and Blagovieshtchensk. Sable furs are sorted into bundles, the contents of each being graded into first, second, and third quality. The bundles are of various sizes, and the percentages of each sort in the bundles also vary. It is impossible to buy bundles of only the first grade or even of the second grade entirely, as no local merchants find profit in buying skins of the lowest quality alone. Sable skins, moreover, deteriorate quickly. In a year their colour becomes lighter, and their market value therefore is cheaper.

The fur of the squirrel grows darker and more downy in regions toward the east, being gray in the Ural Mountains and becoming dark sky-blue in Nerichinsk region. Throughout Siberia where spruce and cedar trees grow, squirrels, owing to their singular fecundity, are abundant and are much hunted. In Western Siberia the most important markets are Obdorsk, Berezov, Muzhi (Berezovsk County), Pelym and Gari (Turinsk County), Surgut and Ugansk (Surgutsk County), Narym, Tymskoie, and Parabelskoie (Narymsk region). In Eastern Siberia the squirrel skins come to the fur markets in larger quantities than in Western Siberia, the largest markets being Turukhansk, Yeniseisk, Irkutsk, and Yakutsk.

The fox is found not only in wooded localities but also on the steppes. The fox of the steppes, called "korsak," has a soft, thick, very warm fur of whitish, brown, or yellow colour. The Siberian fox is larger than the European one, and the colour grows darker in lands toward the east. On the Lena River the colour is dark yellow, and in Kamtchatka dark red. There are also black foxes with a silvery lustre, which cost up to £400 apiece. This is not a new species, but a rare variant in colour. It has been noted repeatedly that wherever there are hares are found also foxes, which feed largely on the hares.

Ermine grow better and larger in Western than in Eastern Siberia. The best are from Barabinsk and Ishim; the next best from Tobolsk, Yeniseisk, and Lena. The arctic fox is found along the coast of the northern Polar Ocean. Its colour is dense white, very

rarely sky-blue. The best quality comes from the Lena region.

The hares, abounding on the open and level localities of the Steppe region, are gray in colour during the summer, and snow-white during the winter. They are better than European hares; the fur is thicker and rubs off less easily. The pelt is also stronger. They bring large incomes to the hunters, not because their fur is so valuable, but on account of their abundance. The best furs are from Turukhansk and in Western Siberia from Kurgan.

Other animals are skunks, the best quality coming from Eastern Siberia; bears, the best quality from Yakutsk; and marmots, the best quality from Trans-Baikal. The skins of the last had the largest demand in Leipzig, for the fur of this animal is best fitted for making imitations of various kinds of fur.

As the area of the hunting grounds has diminished and the number of hunters increased, the quantity of wild animals has also decreased, whereas the demand for furs and the prices have grown constantly.

It is difficult to enforce the hunting laws over such a vast dominion inhabited by so primitive a people. A movement was started to establish natural zoological reservations where hunting would be strictly forbidden; one was in Western Siberia in Turinsk County, Tobolsk Government, and two were in the maritime Province near Olga Bay.

A new business has been created to raise a species of reindeer. The raising of foxes and sables has also been started.

GENERAL NOTES.

AN INTERNATIONAL AUXILIARY LANGUAGE.—Among the documents presented to the British Association at Edinburgh, was an exhaustive report from the Committee appointed to inquire into the practicability of an international auxiliary language. The resuscitation of this problem in official and academical circles is due, primarily to the initiative of the United States representatives at the meeting of the International Research Council held in Brussels in August, 1919. On that occasion, the question was raised of instituting an international abstract journal of chemical literature, but no agreement could be reached concerning the language or languages in which such a journal should be published. Having approved unanimously of the desirability of an international auxiliary language, the Committee turned their attention to the advantages and disadvantages of the following three types: (1) A dead language, *e.g.*, Latin. (2) A national language, *e.g.*, English. (3) An invented or artificial language, *e.g.*, Esperanto or Ido. The views of the Committee are briefly summarised as follows: (1) Latin is too difficult. (2) The adoption of any modern national language would confer undue advantages and excite jealousy. (3) Therefore an invented language is best. Esperanto and Ido are suitable, but the Committee are not prepared to decide between them.

WIRELESS WAVES.—A paper on "The Reception of Wireless Waves on a Shielded Frame Aerial," contributed to the British Association by Mr. Alan A. Campbell Swinton, F.R.S., describes experiments in receiving the spark emission from the Eiffel Tower on a small frame aerial placed inside a tube of wire network with open ends. It was hoped to obtain improved directional properties, but, though the presence of the tube weakened the signals, it was found that altering its direction did not affect them, nor were the signals further weakened by closing the open ends of the tube by wire grids. The tube was next replaced by a sheet copper box with open end. In this was placed, not only the frame, but also the amplifier and all the other apparatus, the telephone being listened to through a rubber pipe. Signals were heard of equal strength with the open end of the box pointing towards, or directly away, from Paris; but ceased when the box was turned so that the open end faced at right angles to Paris, the frame still pointing to Paris; or when the open end was completely closed with a copper or tinfoil cover. In the latter case the signals were still audible unless the cover actually touched the box on all sides. For other positions of the box with the end open, signals could only be heard when the relative positions of the box and frame were such that a prolongation of the plane of the frame towards or away from Paris, no matter which, came out of the open end clear of the copper sides of the box.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Arrangements are being made by the Institution of Automobile Engineers for holding a series of informal meetings before the London, Birmingham, Manchester and Glasgow Centres during the winter. These meetings are designed to consider new accessories in connection with the automobile, such as tyres, carburetters, easy-starting devices, etc. Any firms who have suitable specialities which they are willing to demonstrate at any or all of the centres are requested to communicate with the Secretary, 28, Victoria Street, London, S.W. 1.

BURTON MEMORIAL FUND.—At a meeting recently held at the Royal Asiatic Society it was decided to celebrate the birth-centenary of the late Sir Richard F. Burton, by the institution of an annual memorial lecture, by a medal bearing his effigy and in other suitable ways.

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FRIDAY, SEPTEMBER 23, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

INDIAN SECTION COMMITTEE.

The following is the list of the Indian Section Committee, as appointed by the Council:—

Alan A. Campbell Swinton, F.R.S. (Chairman of the Council).
Sir Charles Stuart Bayley, G.C.I.E., K C.S.I. (Chairman of the Committee).
Lord Ampthill, G.C.S.I., G.C.I.E.
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Sir Henry Trueman Wood, M.A.
Colonel Sir Charles Edward Yate, Bt., C.S.I., C.M.G., M.P.
S. Digby, C.I.E. (Secretary).

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

X-RAYS AND THEIR INDUSTRIAL APPLICATIONS.

By Major G. W. C. Kaye, O.B.E., M.A., D.Sc.

Lecture I.—*Delivered March 7th*, 1921.

The Nature of X-Rays.

The study of the X-rays now occupies such a prominent position in physics and medicine and has led to such momentous results in a variety of directions that one is apt to forget that it is only 25 years ago that the rays were discovered by Prof. Röntgen, and that it was only just prior to the War that a long controversy as to their nature was stilled.

The problem had attracted many minds, for the ability of the rays to pass through opaque bodies was wholly unprecedented. The explanation of the anomaly was obviously bound up with the nature of the rays, but despite shrewd guesses, the secret was withheld from us for nearly 20 years.

We now know that the X-rays are another manifestation of radiant energy, of which light and heat are familiar examples. Indeed, the X-rays resemble light rays in almost every particular, the chief difference

being that the X-rays have wave lengths about 5,000 times shorter. In other words the X-rays are situated away beyond the violet end of the visible spectrum, and may be regarded, in a sense, as a very "treble" form of ultra-violet light. It was this very minuteness of wave length—a distance of the same order as the sizes of atoms—that defeated all our earlier attempts to direct and sort out the rays. All our highest quality polished surfaces are inconceivably rough for such a purpose, and it was not until Nature herself was found to have provided an instrument of the requisite surpassing delicacy—in the shape of crystals which can function as diffraction gratings—that we began to analyse and sort out X-ray beams with much the same ease as in the case of visible light.

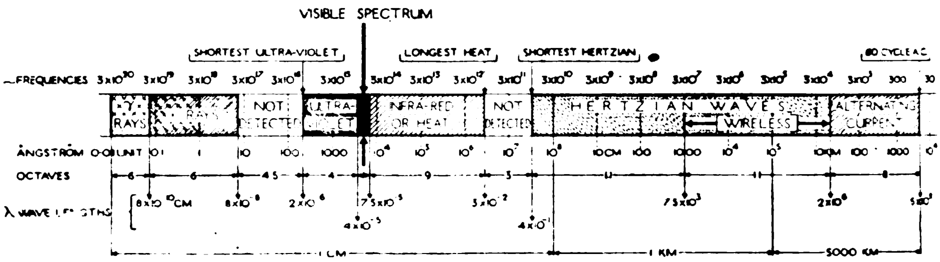

FIG. 1.—RANGE OF ELECTROMAGNETIC WAVES.

There are further parallelisms between X-rays and light rays. For example, we know that the spectrum of a hot body consists under suitable conditions of white light (which is a mixture of all wave lengths) superposed on which are certain spectrum lines whose wave lengths are characteristic of the radiating material, *e.g.*, the D line of sodium, the H and K lines of calcium. In just the same way an element when caused to emit X-rays not only gives out general radiation (which is a continuous spectrum of wave lengths) but under suitable conditions impresses its own characteristic lines on the general radiation. It should be added, however, that the X-ray spectrum of an element is much simpler than its light spectrum.

Just about a single octave of light waves is visible to the eye. Their spectroscopic examination has been conducted mainly with the diffraction grating, the distance between the rulings of which is comparable with the wave lengths to be measured. With the help of special gratings and vacuum spectrometers, Schumann, Lyman and Millikan have extended the measurements some 4 octaves onwards into the ultra-violet. Then comes a gap of 4 octaves of rays in a region not yet explored, and finally some 7 or 8 octaves of X and gamma rays, of which the radiologist uses about 3 octaves. (See Fig. 1).

It is interesting to note that the gap between X-rays and ultra-violet rays has in a sense been already bridged, for Millikan has recently found the characteristic X-ray lines of carbon in the extreme ultra-violet region.

The study of this missing group of octaves bristles with interest and difficulties. It would seem as if a big absorption band were included: at either end of the gap the vacuum spectrometer is necessary. Moreover it almost looks as if the grating method would fail us over this region. The wave lengths are too small for our artificial gratings and too big for crystal gratings. We may have to wait for a new weapon of attack.

Following is a short table of some of the wave lengths, in Angström units, *i.e.*, 10^{-8} cm.

Visible light	7700-3600
Ultra Violet light	3600-200
X-rays	12 to 0.17
γ rays	1.4 to 0.01

X-Rays and Electrons.

Experiment has shown the most intimate relationship between X-rays and the electron—either is the manifestation of the other. Whenever an electron has its speed altered, an electromagnetic wave is produced. If the alteration of speed of the electron is very great, the frequency of the wave is very high, and we get a high frequency or "hard" X-ray. If the change of speed is less, the frequency is less and we get a "softer" or less penetrating ray. With much slower electrons, light rays may be similarly produced. Always, however, we find that

the frequency of the wave is proportional to the energy given up by the electron. There will be a proportion of encounters where the whole of the energy is transferred, and in these cases the frequency will reach an upper limit. Below this limit we find a variety of energy—the contents depending on the experience of the electron involved.

The reverse effect is equally true. If X-rays or light rays strike a substance they may give up all their energy to moving electrons, or they may give up only a part, the rest being transferred to a series of groups of rays, all characteristic of the atom of the material. The energy balance-sheet can be fully written down, and the several items are all definite and specific. The relation is not quite so simple as the general case, but the exchange and partition of energy are equally precise.

The process we have just described is of universal application in Nature. There is, for example, little doubt that the X-rays play a prominent part in atmospheric electricity. The earth is not an electrically neutral body, but its surface may be considered to be covered with a layer of negative electricity, and this gives rise to an electrical field in the atmosphere. The rate of alteration of potential is found to decrease with the altitude: the potential gradient being about 150 volts per metre on the ground, and only about 2 volts per metre at a height of 9 kilometres—as we know by balloon tests. In other words, the atmospheric conductivity steadily increases, the higher we go, and the rapidity of the increase suggests very large values at greater heights.

Some of this conductivity, we know, is due to radioactive emanations from the soil, but we are led to infer from the increase of conductivity with height that the majority is due to some agent external to our globe. Modern opinion favours the view that the effect is produced by very high speed electrons ejected from the sun, and probably moving nearly as fast as light itself. Some of these strike the atoms of the outer atmosphere, very penetrating X-rays are generated, and thus the whole depth of the atmosphere may be permeated by these electrons through the intermediary of the more penetrating X-rays. Thus the earth's negative charge which is being continually dissipated by the action of the potential gradient in the atmosphere is as steadily replenished by a current of electrons passing downwards. It may be added that the conductivity of the air diminishes at night and during a solar eclipse.

One is tempted also to believe that in view of the temperature and gigantic electrical disturbances in the sun—as Hale's work has shown and Eddington's speculations would indicate—there may be an emission of X-rays from the sun itself.

One other source of X-rays in nature may be referred to—the γ radiation of the radioactive elements. It will suffice to say that while some of the γ rays can be exactly imitated, others are much more penetrating than any X-ray we have been able to generate artificially.

Generation of X-Rays.

Although the electron is ubiquitous, it escaped detection until Crookes conducted his famous experiments in discharge tubes at low pressures, and so reduced the number of molecules present, that instead of the electron being absorbed and suppressed within a mm. or so, as it would be at atmospheric pressure, it can now travel great distances without encountering more than say 100 or so atoms, the majority of which it passes clean through without being deviated in any way. The high speed it has received from the potential in the discharge tube gives it, so to speak, an innings.

The electron is indeed the "Cathode ray," and it was by the use of a Crookes' tube that Röntgen first discovered the X-rays in December, 1895.

The present day method is essentially unaltered. The electrons (or cathode rays) are given enormous speeds of the order of 50,000 miles a second, by means of a high tension discharge, and are directed on a heavy block of metal called the anticathode or target. By the use of a focussing device the electrons are concentrated on a small central area of the target, which area is the source or "focus" whence the X-rays set out. As a producer of X-rays the arrangement is extremely inefficient, although we take steps to increase the chances of an effective collision by choosing a target of high atomic weight or number.

Almost all the energy of the electrons is degraded into heat, and for this reason it is essential that the target shall be of a very refractory metal. The great heat developed is removed by water cooling, radiator fins or the like. Tungsten (with a melting point of over 3000° C.) is, nowadays, almost always employed for a target, though

platinum and other metals find use for certain purposes.

All that we need consider for the moment is that the X-rays radiate uniformly in all directions from the focus, travelling in straight lines just as light rays radiate from a lamp. The X-ray bulb is, indeed, an X-ray lamp, in which the voltage applied to the bulb corresponds to the temperature of a luminous lamp. If we raise the temperature of the latter, we increase the intensity and at the same time shorten the average wave length; so with the X-ray bulb, if we raise the voltage we shorten the average wave length. In practice the voltages employed range up to 200,000 or even more. The quantity of radiation is controlled by the current through the tube, and a milliampere is a convenient size of unit for the purpose.

Detecting the Rays.

Although X-rays are not in the visible spectrum, they can be detected photographically or by their power of exciting fluorescence in screens made of salts, such as barium platinocyanide or calcium tungstate. Another method makes use of the ionising ability of the rays and measures the conductivity so produced in a gas. Certain chemical reactions are also induced by the rays, and can be made to serve as the basis of a method of detection and measurement.

X-rays can penetrate all substances to a greater or less degree, and in general, the shorter the wave length the higher is the penetrating power. Chemical combination or temperature is without effect on the absorbing power of an atom. The penetrability of a material by a given beam of rays is governed by the number and mass of the atoms it encounters, that is, by the atomic weight and thickness. We have already mentioned that the rays travel in straight lines, and thus it will be seen that an X-ray photograph or radiograph is essentially nothing but a shadowgraph. Radiography was the first and still remains the most important application of the rays, and as Röntgen himself perceived, a new weapon was put into the hands of the medical man, which was destined to find enormous application. The late war brought this home in unexampled fashion, and no man can overestimate the services which radiology rendered in the great world tragedy. While human endeavour reached its maximum in almost every phase of life, a word may be spared in recognition of the way British radiologists and British manufacturers flung themselves into the gigantic task of expansion.

Mention may here be made of the necessity of protecting the X-ray operator from the rays. As many of the early workers discovered to their cost, indiscriminate exposure results in dermatitis, which may be followed by dangerous cancerous growths. A further danger is impoverishment of the blood corpuscles. Nowadays every precaution is taken, and such casualties rarely occur. Heavy lead screening in some form limits the beam of rays and protects the worker.

THE X-RAY BULB.

There are two main types of X-ray bulbs or lamps in use, (*a*) the hot cathode tube, (*b*) the gas tube. The Coolidge tube, invented by Dr. Coolidge in America, is the chief representative of the first-class, in which the electrons are produced from a cathode consisting of a spiral of tungsten wire, raised to a white heat by an electric current. The vacuum in the tube is very high, and no discharge can pass if the cathode is not heated. The Coolidge tube has the valuable property of precise and reproducible control with a great range, advantages which cannot be claimed for the gas tube. In the gas tube very complete exhaustion is not attempted; a trace of residual gas is deliberately left in the tube, and this serves as a constant source of electrons through shock ionisation by indirect action of the voltage applied to the tube in operation.

If we compare the characteristic curves of these two types of X-ray lamps by

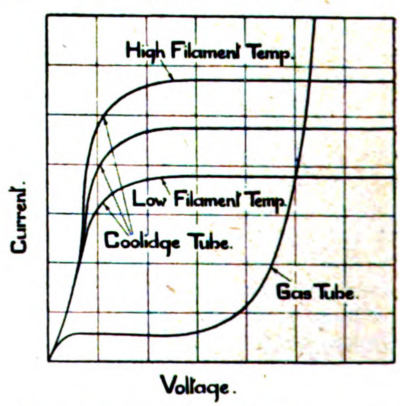

Fig 2.—Characteristic Curves for Gas and Coolidge Tubes.

plotting current against voltage, we find differences which are fundamental. (Fig. 2.) Under the conditions in which a gas tube operates the current increases steadily with the voltage, while in the case of the Coolidge tube the current is independent of the voltage. In the latter case the current is limited only by the number of electrons emitted, which number increases or decreases with the temperature of the cathode filament. Thus we can alter either voltage or current independently of each other, and this fact gives the hot cathode tube a great advantage over the gas tube, in which independent control of voltage and current is impossible.

The hot cathode tube thus utilises its "saturation" current, and for that reason is much less affected by changes in the wave form of the exciting potential than is a gas tube. On the other hand, the absence of saturation in a gas tube leads to a more effective use of very high voltages, and it is found that, at any rate, at low gas pressures a gas tube gives about twice the X-ray output of a Coolidge tube for the same milliamperage and voltage. (Fig. 3,

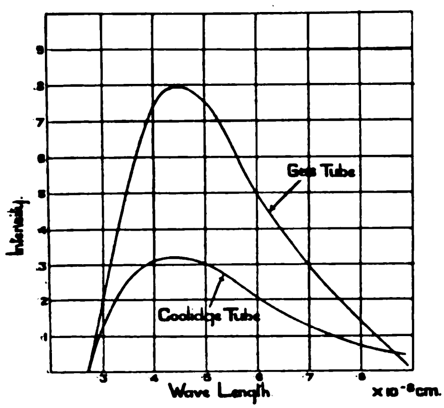

FIG. 3.—X-RAY OUTPUT FROM COOLIDGE AND GAS TUBE, 46,000 VOLTS 1 M.A.

Dauvillier). But the gas tube is far from being the equal of the Coolidge tube as regards control and reliability, though experience counts for a good deal.

It may be added that both types of tube give X-rays with nothing to choose as regards lack of homogeneity.

THE GAS TUBE.

The gas tube depends for its action on the presence of a few ions in the residual gas in the tube. These ions or electrified atoms have their velocities increased by the electric field, positive ions being drawn to the cathode and negative to the anode. The positive ions bombarding the cathode release electrons in abundance which, being attracted to the anode, ionise freely by shock or collision those atoms encountered en route, generating more positive ions and more electrons. The electrons which hit the target generate X-rays and the cycle of operations continues so long as the voltage is applied.

The positive ions or positive atoms on which Sir J. J. Thomson and more recently Dr. Aston, have done such brilliant work, thus play a fundamental and essential part in the ionics of a gas tube. They are also responsible for one or two other effects, the elucidation of which has been very puzzling. One of the great difficulties in exact work with the gas tube is the continual tendency of the gas pressure to change. One would first look to the electrodes which, depending on the conditions, may either emit or absorb gas and do so control very materially the well-known "crankiness" of a gas tube. But it is found that, provided the current is not too heavy to overheat the electrodes, there is a continual and steady disappearance of gas, more especially at high voltages. Various devices are employed to re-lower the vacuum by admitting automatically or at will fresh gas to replace that which has so mysteriously disappeared. Otherwise the vacuum becomes so high as to render the tube unusable. To cut a long story short, we now know that some of the positively charged atoms of gas by reason of their high velocity actually crash into the glass walls of the tube and are mechanically trapped there, an effect which is enhanced by the presence of volatilized metal. Incidentally this also accounts for the positive electrification on the greater part of the walls. It may be added that the positive rays are also responsible for the pitting of the cathode and the glass stem round it, and without a doubt they have produced many punctures in that region.

The variation in gas pressure is also very liable to produce spasmodic displacement of the focal spot, an effect prejudicial to definition in radiography.

The gas tube has received a good deal of attention in Germany during the War. In the so-called "boiling tube" of Müller, the gas tube is employed to generate very penetrating X-rays primarily for use in

deep therapy. The gas pressure is very low and tending to get lower. To prevent emission of gas from the (platinum) anticathode, it is kept at a constant temperature by boiling water, and water-cooling is also adopted for the cathode. The focus is very broad. There is a supplementary bent wire anode, which during the final stages of exhaustion helps to remove the last traces of gas. The tube is operated at about 200,000 volts and with small currents, 2·3 milliamperes, a condition which assists the hardening tendency. Puffs of gas are introduced by an osmosis tube heated by a small flame ignited and operated through a relay by an automatic regulator which is controlled by a milliammeter in series with the X-ray tube. In action the water quietly boils and the tube may be run for hours at a time at a constant milliamperage. It or reconstruction of Coolidge tubes does not on this score present the same difficulties as in the original manufacture.

The residual gas plays little or no part and positive rays do not operate appreciably in the functioning of the tube. Unless the cathode is heated it is impossible to send a discharge through the tube. The focal spot does not wander or vary in size as it does in a gas tube.

In prolonged use of a Coolidge tube a small amount of gas is usually liberated, as is indicated by a small drop of the milliamperes through the tube, which can be corrected by raising the filament temperature; such gas is promptly re-absorbed when the discharge is stopped.

In the radiator type of tube, the heavy massive target of tungsten is kept cool by radiator fins. (Fig. 4.) This type of tube is claimed that there is a greater proportion of homogeneous end radiation when the X-rays are filtered than there is from a Coolidge tube working under the same conditions.

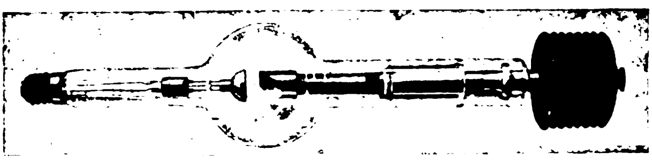

FIG. 4.—COOLIDGE TUBE, RADIATOR TYPE.

Whether that is so or not, it must not be forgotten that an increase of potential always tends to render a beam more homogeneous. Further, the spark gap readings on a gas tube tend to indicate voltages higher than those which are effectively operating the tube.

THE COOLIDGE TUBE.

In 1913, Dr. W. D. Coolidge introduced his now well-known X-ray bulb, which formed one of the landmarks in the history of the subject. The electrons are furnished by a hot spiral of tungsten, which is mounted within a focussing tube or bowl of molybdenum. The gas pressure is some 20 times lower than that of an average gas tube, special care being taken to free the electrodes and bulb as far as possible from gas. The pre-heating of the electrodes is found greatly to facilitate exhaustion. The electrodes can be left about in the air for some days before use. The repair

can, within limits, act as its own rectifier, so that it can be operated direct from a transformer. A recent development is a small radiator tube with walls of lead glass ¼in. thick, a small window of soda glass allowing a pencil of rays to emerge. The lead glass serves to protect the operator from radiation.

The G.E.C. of America has adopted the methods of mass production of the various forms of Coolidge tube, and is now turning out over 100 tubes a day. The bulbs and glass parts are blown in moulds at the glass factory, and the operation of assembly is carried out by girls with the aid of glass blowing machines. An incidental advantage is the resulting uniformity of size of the glass bulbs.

There is one feature of the Coolidge tube to which reference should be made. As already remarked, in consequence of the low pressure "shock" ionisation of the residual gas is negligible or practically so, and it is left to the electrons to do all the carrying of the current. Thus the space between the electrodes is filled with carriers of one sign, with the result that at high current-densities, there is an appreciable obstructing

effect due to electrostatic repulsion between the electrons crossing over and those following. This "space-charge" sets an upper limit to the current through a Coolidge tube at high filament temperatures. (Fig.

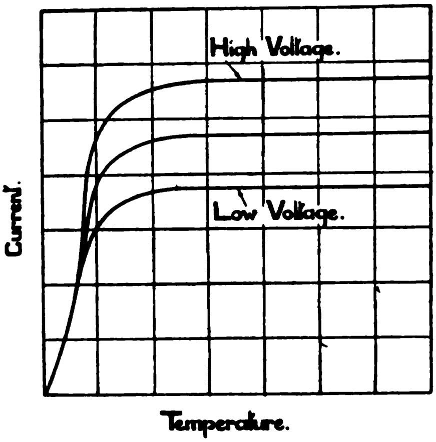

FIG. 5.—RESTRICTING EFFECT OF SPACE-CHARGE ON CURRENT THROUGH A COOLIDGE TUBE.

5.) The restricting effect of the space-charge can be lessened by raising the voltage, or by introducing positive ions in some fashion, *e.g.*, by a trace of gas. In the case of very heavy momentary discharges, tungsten vapour is produced at the focal spot, and this also serves greatly to diminish the tube resistance.

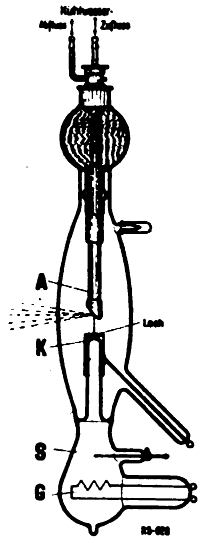

FIG. 6.—LILIENFELD TUBE.

At high voltages (above 120 kv. and up to 170 kv.), the rays after filtering through 3 mm. of aluminium are stated to be homogeneous.

METAL X-RAY TUBES.

From time to time various experimenters have worked with metal bulbs in an attempt to get rid of some of the energy limitations imposed by glass. Sir Oliver Lodge designed such a bulb in 1897, and since then Coolidge (Fig. 7), Siegbahn and others have made

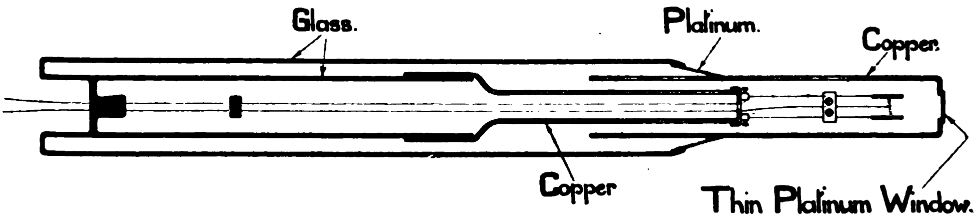

FIG. 7.—METAL X-RAY TUBE (COOLIDGE).

LILIENFELD TUBE.

The Lilienfeld tube introduced in 1913, and since extensively modified, may be said to act as a combination of hot cathode tube and gas tube, and incidentally is claimed to possess the advantages of both. In an annexe to the main discharge tube, a hot cathode is separately excited by a moderate potential. (Fig. 6.) The electrons pass through a hole in the main cathode and are there subjected to a much higher potential difference before they strike the anticathode. Lilienfeld lays stress on the importance of using a coil discharge as yielding high momentary current densities.

use of them, and it is probable that future commercial developments will be on such lines. It may be added that Coolidge has also made water cooled glass tubes, which absorbed up to nearly 20 kw. or about 27 H.P. Coolidge and others have also used silica bulbs.

THE HIGH-POTENTIAL GENERATOR

The voltages which obtain in practice for exciting X-ray bulbs are, roughly speaking, of the order of up to 100,000 volts for radiography and superficial therapy; and up to 200,000 volts or more for deep therapy and radio-metallography.

The high-potential generator is almost always a step-up transformer. Less commonly, especially in this country, influence or static machines are employed, though they would have many advantages if they could be sufficiently improved to withstand atmospheric humidity.

It is customary in radiology to speak of "induction coils" and "transformers," though both are varieties of step-up, static, high-tension transformers. By an induction coil is meant an open-cored transformer which depends for its action on the interruptions of the primary current by an independent break or interrupter. By a transformer is implied a closed-core transformer, fed with alternating current (almost always single phase), either straight from the main or (in the case of a D.C. supply) from the alternating side of a rotary converter. Such a transformer may be either oil-immersed or have "dry" insulation.

The coil ordinarily yields a "peaky" potential wave as compared with the approximately sinusoidal wave form of the transformer. With both types some sort of valve or mechanical rectifier is employed, either to cut out or invert the half of the high-potential wave which would tend to pass in the wrong direction through the X-ray bulb. In the case of a coil and rotary interrupter the mechanical rectifier is a commutator mounted on an extension of the spindle of the interrupter. In the case of a transformer, a similar commutator is mounted, either on the shaft of a synchronous motor (if A.C. supply is used), or on an extension of the shaft of the rotary converter, as the case may be. If a valve is used instead, there are several types available, but choice is practically restricted to the hot cathode type, such as the Kenetron As already remarked, Coolidge tubes of the radiator type are self rectifying.

The initial cost of a transformer outfit is approximately twice that of an induction coil outfit of corresponding power. A transformer outfit is rather more bulky, and any repairs are also usually more expensive. On the other hand, the efficiency of a transformer is roughly twice that of a coil (including a break and rectifier). Further, owing to the occasional vagaries of all interrupters, control is more precise and measurements are more definite with the transformer and, if A.C. is available and we dispense with the mechanical rectifier, there are no moving parts. Transformers produce greater heating effect on the target of the X-ray bulb, but this objection is met by arranging the rotating commutator so that it picks off only the regions round the crests of the loops, and thereby eliminates the less efficient lower voltages.

The induction coil is an empirically designed instrument, the present-day type of which is not fundamentally very different from the early models of Spottiswoode, although in detail it differs very considerably. The exact measurement of the performance of coils is difficult and, as a consequence, coil makers have been led to adopt certain arbitrary standards of design, which are based chiefly on practical experience. Some of the features which arise in the design are conflicting, and it is in the methods of reconciling necessarily antagonistic factors that the skill of the coil designer finds chief scope.

The subject of induction coil design for X-ray purposes is a large one and only certain broad conclusions can be touched upon here. A transformation ratio of from 50 to 200, and an efficiency of 0.3 to 0.6 are usual figures. Some form of sectional winding is adopted for the secondary coil, allowing about 4000 volts for every 1000 turns, and arranging that the outside diameter does not exceed 2½ times the bore. The resistance and, more especially, the self induction of the secondary must be kept down. The primary should be capable of being connected directly to the 200 volt mains. The capacity of the condenser should be no greater than will prevent undue arcing in the interrupter. The interrupter should run at as high a speed as is expedient and be of adequate design and robust construction.

About 15lbs. of iron core should be allowed for every kilovolt-ampere input. The core may well have a length in the neighbourhood of up to 10 times the diameter. The primary windings should extend over almost the whole length of the core; the secondary windings over not more than the middle three quarters, though care must be taken that this (the length of the secondary) is at least 4/3 times the maximum spark length.

The induction coil is essentially a shock apparatus, and the shock-excitation method of interruption may result in the presence of many superposed harmonics in the oscillation waves. These harmonics, which have high frequencies (several thousands a

second) are reflected in the secondary circuit where, from a practical point of view, they evince themselves in the reluctance with which they pass through an X-ray bulb. The resulting tendency to spark across the surface of the tube can only be met by lowering the gas pressure, by immersing the tube in oil, by lengthening the arms or, of course, by suppressing the high frequency waves before they reach the tube.

This is done in the so-called "symmetrical coil" which has been developed in Germany. In this apparatus two separate coils mounted vertically side by side, have their secondaries connected in series and also their primaries. In the two connecting leads between the secondaries are inserted a gas X-ray bulb in the one and an enclosed rectifying spark-gap in the other. On each side of the spark-gap and in series with it is a high resistance (water). The self induction of the secondary circuit is low, but the resistance is very high and serves to damp out the high frequency oscillations. The spark-gap helps to enhance the break-down potential of the gas bulb. High voltage (200,000) and low current (2 to 3 m.a.) are aimed at. An annular air space between primary and secondary assists natural cooling. A mercury break ($\sim = 47$) is used.

Mr. Mortimer Codd has designed a somewhat similar apparatus in this country.

Interrupters.

Much of the progress that has been made with the performance of coils has resulted from the proper selection of interrupter. The hammer break, the accompaniment of most of the earlier coils, is now rarely fitted. The majority of present-day interrupters are of the motor-driven type which employ mercury in a dielectric either of coal gas or a liquid such as paraffin oil. A large proportion of mercury interrupters are of the turbine variety in which a jet of mercury is pumped against a series of rapidly revolving vanes.

The electrolytic or Wehnelt interrupter still finds favour with some workers. In the usual form it consists of two electrodes immersed in dilute sulphuric acid. The cathode is a large lead plate, the anode consisting of one or more platinum points, the exposed amount of which may be controlled by an adjustable porcelain sleeve.

There is still scope for much work on the design of interrupters, which may fairly be said to be the most untrustworthy feature of a present-day coil outfit. A large amount of energy is wasted in the interrupter, especially with heavy currents.

GROWTH OF CO-OPERATIVE SOCIETIES IN GERMANY.

Notwithstanding the many changes of an economic nature that have occurred in Germany during and since the War, the co-operative societies have not only survived but have even prospered.

The development of these societies within Germany has been purely German in its character. According to a report by the U.S. Commissioner in Berlin, little has been borrowed from experiences of similar institutions in other countries. The co-operative societies, coincident in growth with the industrial development of the countries wherein they were situated, reached their maximum of power during the last 15 years of the nineteenth and the first 15 years of the twentieth century. In England the greatest development has been attained by the consumers' societies; in France by the producers' societies; and in Germany the most rapid growth took place in the workmen's co-operative societies.

The man who instituted the most successful form of co-operative society in Germany was Hermann Schulze-Delitzsch. In 1849, while a member of the Prussian Assembly, Schulze established the Raw Material Union for Joiners, the first association embodying ideas now governing co-operative societies. From the start Schulze-Delitzsch was opposed to all forms of Government assistance, wishing the workman to be free equally from the restrictions of capital and of the Government.

In 1864 the Central Office of the General Federation of German Trade and Economic Co-operatives was founded. Its objects were the furthering of co-operative life in general, the advancement of study in economic conditions, and the establishment of confederated co-operative societies. Many different classes of co-operative societies were formed to meet the various needs of the artisan, of the farmer, and even of the tradesman. A sub-division of the various types of "co-operatives" has been made into 18 classes, as follows:

Credit co-operatives.
Raw material co-operatives—industrial.
Raw material co-operatives—agricultural.
Material purchasing co-operatives.
Labourers' co-operatives—industrial.
Labourers' co-operatives—agricultural.
Co-operatives for providing machines, etc.
Warehouse co-operatives—industrial.
Warehouse co-operatives—agricultural.
Combined material and warehouse co-operatives—industrial.
Combined material and warehouse co-operatives—agricultural.

Producing co-operatives—industrial.

Producing co-operatives—agricultural: (a) Dairy co-operatives; (b) distillery; (c) vineyards; (d) co-operatives for the production and sale of field and garden fruits; (e) slaughter-house; (f) fisheries; and (g) forest exploitation.

Breeding co-operatives.

Consumers' co-operatives.

Dwelling and construction co-operatives.

Dwelling and construction co-operatives for the establishment of communal houses.

Miscellaneous.

The co-operatives had enjoyed under Prussian law very few judicial rights. They were forbidden to own land or dwellings, to establish factories, except for the use of their own members, nor had they a corporate personality whereby they could sue and be sued in the courts. It was not until March 27th, 1867, that the law was finally passed which gave them corporate personality. In the years immediately following, laws of a similar nature were passed in various sections of the German Commonwealth, a law applying to the whole Commonwealth being adopted by the Reichstag on August 1st, 1873. This law was considerably altered in 1889. Limited liability was admitted and sales by the consumers' co-operatives to any but co-operative members were forbidden. In the final form the law provided for obligatory inspection of the various co-operatives, the cost of inspection to be borne by the co-operatives themselves. This fact encouraged the formation of central federations of the different types of co-operatives, primarily as an arrangement for sharing the expenses of inspection. Later, of course, other advantages in the central federations were discovered, especially the centralisation of capital and the increased scope of activities thereby opened.

A contemporary of Schulze-Delitzsch, Friedrich Wilhelm Raiffeisen, was particularly interested in co-operatives for the benefit of farmers. Moreover, he endeavoured to establish in the co-operatives a religious feature. As a result of his efforts the agricultural and farm-credit co-operatives have had, to some extent, a philanthropic and religious character, having often discriminated in favour of persons on account of moral or religious grounds. The form, however, has not been as successful from a business point of view as the one advocated by Schulze-Delitzsch.

Although the Schulze-Delitzsch co-operatives had had no religious tendencies, when they combined, in 1903, with the Raiffeisen co-operatives they exerted thereafter a strong religious influence.

Among the types of co-operatives established by Raiffeisen the most successful was that of the supply co-operatives, whose aim was to supply the farmers with the best quality of seed, fertilisers, and other articles necessary for the highest development of agriculture. The question of the price was always secondary to that of the quality. A further development of this type of co-operatives was the Werkgenossenschaften, whose object was to improve the breeds of cattle by the communal use of bulls, rams, and other blooded stock. There were also producers' co-operatives, which dealt with dairy products, poultry, etc.

The Prussian Government early established co-operatives of its own which entered into competition with the Schulze-Delitzsch type of co-operatives. The latter also encountered the resistance of the retail traders, who felt that the co-operatives, especially the consumers' co-operatives, were a menace to their existence. They soon found, however, that certain types of co-operatives, as, for instance, the Purchase and Warehouse Co-operative, could be of great assistance to them in the carrying of stock and in economy of buying, provided they became members.

Of all forms of co-operatives that of the consumers' co-operatives has probably had the most severe struggle. The small retailers have never ceased to fight it. Their propaganda has resulted in the elimination of practically all bourgeois elements from the consumers' co-operatives, but on the other hand the number of workmen who have become members has reached a high figure.

Co-operatives in various forms have been established for particular groups of people. The only one, however, that had much significance was the State Employees' Co-operative, which reached a certain development in the early years of this century, but has since been declining in importance.

An examination of the figures for co-operative membership shows that the principal gain from 1915 to 1917 has been in the consumers' co-operatives, and that in spite of their smaller number of organisations their membership has grown beyond that of the credit co-operatives. The seven groups of consumers' co-operatives are as follows: Federated Union of Business and Industrial Co-operatives Founded on Self-Support; Union of German Agricultural Co-operatives for the Commonwealth; General Union of German Raiffeisen Co-operatives; Central Union of German Consumers' Associations; Head Union of German Industrial Co-operatives; Revision Unions (which do not belong to the big Central Unions); and those belonging to no union. The predominating rôle of the Central Union is apparent, since it had in 1916 a liability which amounted to 73 per cent. of the total liability of all the unions and had 72 per cent. of the total membership. It is also worth noting that a very small proportion of the societies have unlimited liability.

As to the important development of the consumers' societies in recent years, figures show a growth in membership from 781,637 in

1903 to 2,562,733 in 1919. The Central Union has 2,231,917 members.

The Central Union has its headquarters in Hamburg, from which point its foreign purchases are made through the purchasing division of the union, previously to the war, operating in entire independence, during and since the war operating under the control of the Commonwealth Purchasing Office. Warehouses are maintained in Hamburg for foreign and domestic purchases, whence distribution is made to the headquarters in the various cities of the nation. The union has found it advantageous to build its own plant for the production of certain articles in continuous demand. For example, it has several large soap factories.

The head office in Berlin is partly warehouse, partly factory, partly bank, and is typical of similar institutions in other cities. Stocks are carried for distribution to the various branch stations in different parts of the capital, distribution being made daily by motor trucks, so that there is no necessity for great accumulation of stocks in the shops. Goods are unpacked from bulk and repacked into small parcels convenient for handling. Baking of bread and of small cakes is done on a large scale under hygienic conditions and with modern appliances. The management has introduced a banking system for saving accounts of members and their children and the accounts now run into more than 10,000,000 marks. Employees are housed in most modern workmen's dwellings belonging to the union. A spirit of industry and fellowship is apparent throughout the entire plant, a condition showing that the co-operative feeling is a fact within the organisation and not simply a business theory.

PRODUCTION AND USES OF MEXICAN SESAME SEED.

Sesame seed is one of the articles of Mexican agricultural production capable of great development. There are two easily distinguishable varieties of sesame, the white and the brown. Both are produced in Mexico; the white is also extensively harvested in Northern Africa, Japan, the South Pacific Islands, and other tropical and sub-tropical countries. There are said to be 19 varieties in Africa, where the seed has been cultivated since remote times. The plant is known as sesame in Spain, France, England, and the United States, while it is called ajonjoli in Mexico, having there the same derivative root name that it bears in the East Indies. There is no doubt that this plant has been harvested in India for at least 300 years, and it is believed that it was brought thither from Africa.

Sesame is produced in Mexico principally in the States of Michoacan, Guerrero, Morelos, and Vera Cruz. Smaller quantities are also obtained in the States of Puebla, San Luis Potosi, Hidalgo, Colima, Tabasco, Tamaulipas and Chiapas. As stated in a report by the U.S. Trade Commissioner in Mexico, the climate of these States, and particularly those first mentioned, is remarkably adapted to the cultivation of this plant, and unlimited possibilities may be said to exist throughout Mexico, except in the high altitudes, for a production considerably in excess of the present output. Authoritative and expert opinion testifies that the only requisite needed to produce an almost unlimited supply is increased utilisation of the area now lying idle. In view of the world demand for edible oils, there is reason to expect a development along this line in the near future.

The oil content of sesame, according to a Mexican Government estimate, is 50 per cent. Others place the content at 56 per cent. Apart from this, the pulp is highly nutritious. In view of these facts, sesame compares favourably with the cotton seed in food value. It is almost equal to the olive in oil content, and in taste, odour, and adaptability for commercial uses it is said to be quite as desirable. The processes utilised in the extraction of sesame oil are considerably more modern than the methods commonly employed in the extraction of olive oil in Italy and Spain. The white variety of sesame is said to be richer in oil content than the two sub-varieties of black or brown sesame. On the other hand, the latter seeds fructify in a shorter time and a greater number of crops within a given period may be produced.

There are 15 factories of different sizes and of varying importance in the City of Mexico engaged in the extraction of sesame oil and in its preparation for market. The greater number of these, however, are one-press factories with very slight capacity. The largest are in the hands of Spaniards. The principal output is oil, most of which is consumed domestically. A considerable amount of the oil is sold by grocers as an imitation of olive oil. There are three extractions of oil from the seed. The first two are made cold, while the final one is made of the heated pulp. The first oils are almost odourless, and the inferior grades are rancid. The oil, as well as the seed, was formerly exported to Germany, and recently a large shipment was made to Holland. There is also a large consumption of the oil in France, where Marseilles is the centre of the extraction industry.

The first-grade oil is employed for seasoning, and for the same miscellaneous culinary purposes that olive oil and lard are used for. The better grades of oil are used also in the manufacture of oleomargarine and to adulterate other edible oils. The inferior oils are used for soap making, as a combustible, and as a basis for perfumes. The leaves of the sesame have medicinal value and contain gelatinous substances. The pulp

which remains after the oil is extracted is valuable as stock food. It is used in Mexico as food for cattle, hogs, and poultry. It is compressed into oil cake, in which form it is readily shipped. A considerable amount of this is exported, one factory recently having shipped 1,500 tons to a single destination in the United States. It has also been shipped to Holland and Germany. It is estimated that the oil cake of sesame contains 60 per cent. food value.

SHELL TRADE OF THE DUTCH EAST INDIES.

The shells exported from the Netherlands Indies are divided by the customs authorities into four divisions: Pearl (called M. O. P. for mother-of-pearl), troca, burgos, and flores. By the trade the shells are divided into two classes, white M. O. P. and yellow lip M. O. P. According to a report by the U.S. Trade Commissioner in the Netherlands Indies, the white M. O. P. comes chiefly from the Aroo Islands off the coast of New Guinea. The pearl-fishing concession for those islands is held by one company, having its head office in Macassar, Celebes, the principal market in the Netherlands Indies for shells. Other white M. O. P. come from the islands in the neighbourhood of Ternate, in the Moluccas. The yellow M. O. P. have a yellow border around the edge or "lip" of the shell. The quality is said to be inferior to that of the white shells. They are found in the waters close to the island of Ceram, off the island of Tanimbar, off the Bangaai Archipelago, and near the islands of Timor and Flores. Three fleets, two European and one Arab, are operating on a large scale, and native fishermen also send considerable quantities of shell to Macassar.

Burgos or "green snail" shells come from the waters of the smaller Sunda Islands, Timor, Flores, Sunda, Sumbawa, and other islands. Only native fishermen are engaged in this industry. Before the War exports of these shells were somewhat evenly divided between the United States, Great Britain, Germany, and France. By 1918 the exports dropped almost to the vanishing point, largely owing to the prices offered. Since then the United States has been in the market for small quantities, while considerable shipments have been going to Japan.

Troca shell fishing is also a native industry in the same waters where the Burgos shells are found. France took the major portion of these shells before the War, while large quantities went to Penang and Singapore. To-day Japan is paying prices that draw practically the whole production to her factories. This shell is of poor quality, making a very cheap button.

Flores shells also come from the smaller Sunda Islands, and the fishing is all done by the natives. Before the War much the largest part went to Germany and Austria. The decrease in demand due to war conditions has cut down the production of this industry materially, but such as it is the export goes now most largely to Japan. The shell is small and of a poor quality.

The following table shows the exports of shells in metric tons (metric ton = 2,204 pounds), by countries for 1913 and 1918:—

Exported to—	1913.			
	Pearl.	Troca.	Burgos.	Flores.
Netherlands	40	—	—	2
United States ...	13	—	35	—
Great Britain ...	420	—	26	—
Germany...........	4	10	30	117
France..............	49	726	41	14
Penang & Singapore	26	578	7	7
Hong Kong	2	3	—	—
Japan	4	—	1	1
Total	558	1,317	140	141

Exported to—	1918.			
	Pearl.	Troca.	Burgos.	Flores.
Netherlands	—	—	—	—
United States ...	63	—	—	—
Great Britain ...	—	—	—	—
Germany	—	—	—	—
France..............	—	—	—	—
Penang & Singapore	27	218	9	7
Hong Kong	4	—	—	—
Japan	6	1,135	1	50
Total	100	1,353	10	57

THE GERMAN VEGETABLE FIBRE INDUSTRY.

The attention of textile manufacturers has been attracted to the remarkable results that are being attained in Germany in the manufacture of yarn from grasses, plants, leaves, etc. This new German industry is centred in the plant of the Deutsche Faserstoff-Gesellschaft (German Fibre Material Co.) situated at Fuerstenberg, in Mecklenburg.

According to a report by the representative in Germany of the United States Department of Commerce, this plant was established in 1912. During the first year in which it was in operation it confined its activities to the manufacture and sale of the fibres. In 1913 spinning machinery was set up, and since then the spinning has been carried on on an ever-increasing scale. The fibres dealt with include China grass, Australian

seaweed, jute, old jute rags, and shoddy worsted yarn. In addition, a number of other fibres were worked up during the War. Some were abandoned afterwards, as the supply to be found in Germany was not sufficient to warrant their permanent use. Among these fibres are nettle, hops, willow bark, pine needles, cornstalks, ginster and asparagus. With the fibre taken out of pine needles and cornstalks a very strong and tough paper can be produced.

Prior to the outbreak of war, the Deutsche Faserstoff-Gesellschaft was able to secure sufficient supplies of China grass, Australian seaweed and jute, and it focussed its efforts on these fibres. During the war, the imports of this raw material were cut off and had not, at the date of the report, been resumed. Since the close of the war this concern has confined itself mainly to the manufacture of yarn from old jute rags.

The vegetable fibre derived from China grass is known as solidonia, and is similar to ramie. The Deutsche Faserstoff-Gesellschaft by means of a special process produces a long, fine, soft and curly fibre. The curliness of the solidonia fibre presents a special feature. This fibre looks very much like wool and mixes readily with that product, thus opening a wide field for its use in the woollen industry.

In Germany, solidonia gained a wide field of use on account of the shortage of wool during the war. As a substitute for linen, solidonia has been used in Germany for the manufacture of table linen of beauty and strength. It has also been used for machine belting. German hosiery and underwear mills have produced from it socks and stockings which are difficult to tear, and unshrinkable under wear, and sporting jackets of fine quality and strength.

The German woollen mills have manufactured an army cloth which, composed of 75 per cent. wool and 25 per cent. solidonia, it is asserted surpasses in tensile strength any pure-wool cloth. Similar results are claimed with respect to paper-makers' felts, which, with a percentage of solidonia mixture, show a considerable increase in strength. Furthermore, women's and men's clothing composed of half solidonia and half wool or shoddy, especially in piece-dyed goods, have found a ready market. In textile circles in Germany it is declared that there is an unlimited field for the use of this fibre. Previous to the war the price of solidonia in Germany was two-thirds the cost of good staple wool. No post-war comparison can be given, as none of this raw material is being imported into Germany. In 1914 solidonia in the carded stage found a ready market at 30 cents (1s. 3d.) a pound, delivered in New York or Boston.

Another fibre from which the Deutsche Faserstoff-Gesellschaft has obtained splendid results is the fibre known as posidonia. This is also a vegetable fibre. It is derived from seaweed, which is dredged in Australia and cleansed and washed in sweet water. Brought to Germany the fibre is subjected by this concern to a chemical treatment for the purpose of softening it and making it resilient, the original fibre being stiff, harsh and brittle. The staple of this fibre is declared to be equal to a medium staple wool, and it is spun on the worsted and woollen system. It is characterised by elasticity and springiness, and the cloth which is made out of pure posidonia appears to show scarcely any creases. German cloth mills have mixed posidonia with wool or shoddy, and cloth of good strength and appearance has been obtained. It is believed that this fibre, by reason of its springiness, will have a wide field of use in the carpet industry. This raw material was sold at half the price of shoddy before the war; since the war none of this has been imported into Germany.

Some unusual results have been obtained with jute by the same company. By a special process of chemical treatment a long, fine, and beautiful fibre is being produced therefrom, a fibre which can readily be spun on the worsted system, pure or mixed with wool. Shoddy made from old jute rags can also be spun on the worsted or woollen system. Serges made from old jute rags or cloth made from half wool and half jute, wool or piece dyed, are used for women's costumes, overcoating, etc. Furthermore, sweaters and vests are being made from all jute worsted yarn, and it has been difficult to recognise them as being made of such. The Deutsche Faserstoff-Gesellschaft claims that jute represents the cheapest fibre suitable for worsted yarn that has been discovered.

The Deutsche Faserstoff-Gesellschaft has moreover succeeded, by a special opening process, in manufacturing shoddy of sufficiently long staple to spin a high-grade worsted yarn from it.

This plant began work with a total of 15 employees. Its personnel now numbers over 250. The buildings have been enlarged and new ones erected, and plans are on foot to make still greater additions.

GENERAL NOTES.

INSTITUTION OF GAS ENGINEERS.—The annual meeting of the Institution of Gas Engineers is to be held, under the presidency of Mr. Thomas Goulden, M.Inst.C.E., Chief Engineer of the Gas, Light and Coke Company, on the 11th and 12th October, at the Central Hall, Westminster. On the following day the fuel research station at East Greenwich will be visited. The meeting was to have taken place in May, but was postponed owing to the industrial unrest.

COFFEE PRODUCTION IN SANTA MARTA (COLOMBIA). — In a comprehensive report on the coffee industry in the Santa Marta District of Colombia, the United States Consul at Santa Marta states that 1,036 hectares on the slopes of the Sierra are now producing coffee, which is but a small fraction of the total land available for exploitation. The largest plantation is under American control and management and has 425,000 coffee trees planted. For the year 1919, it produced 3,600 hundredweight of hulled coffee, nearly all of which was first and second grade in quality. It is estimated that 1,958,600 coffee trees are planted in this region. During 1919 the total production of the district was 1,184,100 pounds, all of which with the exception of 10,000 pounds consumed locally, was shipped to the United States. The Consul asserts that the Santa Marta variety compares well in all respects with other coffee raised in Colombia, that from the Medellin district alone obtaining a higher price ; it is quoted on a par with the coffee known as Bogota, and is superior to the Bucaramanga product. Possibly local wages are higher than in other sections of Colombia, although facilities for transportation and accessibility to port of shipment will more than offset any advantages possessed by planters of the interior, many of whom, during the serious freight congestion on the Magdalena River during the first half of last year, were unable to market their coffee.

FIBRE CASES FOR SHIPPING RUBBER.—Of considerable interest to rubber shippers in British Malaya and of great importance to rubber manufacturers is the recent introduction of a new type of shipping case into Singapore shipping circles by a representative of an American company. The United States Consul at Singapore writes that these cases, made of 100 per cent. fibre, come from the manufacturer in the shape of sheets, the riveting, packing, and wiring being done by local shippers. The cases hold from 225 to 250 pounds of sheet rubber, as compared with 200 pounds contained in the wooden chests, at no sacrifice of surface space, by reason of the thinness of the incasing walls. Their practically nonbreakable quality and absolute cleanliness have been proven, while it is claimed that they are waterproof.

INDIAN JUTE AND SILK.—An interesting volume on Indian jute and silk has just been published by Mr. John Murray (price 5s.) in the series of Reports of the Indian Trade Enquiry conducted at the Imperial Institute. The first part of the volume deals with the results of an enquiry into the possibility of the increased commercial utilisation of jute and allied Indian fibres. The section devoted to silk consists of (1) a report on the question of the prospects of an increased utilisation of Indian silk within the Empire, and (2) a detailed statement prepared at the Imperial Institute on the silk trade of the world. The production of raw silk in India at present is insufficient to meet local needs, and large quantities of both raw silk and silk yarn are imported for use in the Indian mills. The opinion is expressed, however, that the enhanced value of Indian silk which would result from a radical improvement in its quality and standard of reeling should render it possible for the Indian product to compete successfully with Japanese and Chinese silks. The types of silk, both cultivated and wild, which are most likely to find a market in the United Kingdom are indicated.

PIMENTO-LEAF OIL IN JAMAICA.—The Government laboratory of Jamaica has been conducting experiments for the production of pimento-leaf oil from pimento leaves. It has been found that pimento leaves yield about 1.8 per cent of eugenol, from which iso-eugenol and vanillin can successfully be obtained. It has also been found that iso-eugenol can be produced by the appropriate fermentation of pimento leaves. As eugenol is of high antiseptic powers, it is thought, reports the United States Consul at Kingston, that this pimento-leaf oil would find use as an antiseptic constituent of tooth pastes and toilet preparations, besides serving for the manufacture of vanillin. If a market can be found, Jamaica can produce 100,000 pounds of pimento-leaf oil per annum from materials at present wasted.

TOBACCO INDUSTRY OF SAMSOUN.—The tobacco-growing region of Anatolia, which has the Samsoun market as its outlet, covers the districts of Samsoun, Baffra, Alatcham, and Tashova, in all about 37,000 acres. From this region approximately 80 per cent. of the higher grades of filler leaf tobacco is shipped to the United States. The Samsoun district is sub-divided into five districts, namely, Dere, Maden, Djanik, Evgaf, and Karagöl. The Baffra district, lying west of the town of Samsoun and situated on the Kizil Irakm River (the largest river in Anatolia), produces tobacco similar in quality to that of the Samsoun district, but a much larger leaf. The Alatcham district lying west of Baffra, produces tobacco inferior in grade to that of the other two districts. Many of the villagers, writes the U.S. Consul at Samsoun, gain their entire livelihood from the cultivation of tobacco. Cultivation is carried on by old, primitive methods. Picking generally begins about the 1st July, but may be delayed by atmospheric conditions to as late as the 15th or 20th. The yield varies from about 120 to 276 pounds per deunum (about one-fourth acre), according to the zone of cultivation. The baled product is transported to Samsoun for shipment. The 1920 crop was estimated at about 10,000,000lb.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2

NOTICE.

DOMINIONS AND COLONIES SECTION COMMITTEE.

The Dominions and Colonies Section Committee, as appointed by the Council, is as follows:—

Alan A. Campbell Swinton, F.R.S. (Chairman of the Council).
Lord Blyth (Chairman of the Committee).
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Allen, Col. Hon. Sir James, K.C.B., M.A., (High Commissioner for New Zealand).
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S. Digby, C.I.E. (Secretary).

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

X-RAYS AND THEIR INDUSTRIAL APPLICATIONS.

By MAJOR G. W. C. KAYE, O.B.E., M.A., D.Sc.

LECTURE II.—*March* 14*th*, 1921.

THE MEASUREMENT OF X-RAYS.

The output from an X-ray bulb must be specified with respect to (1) mean wavelength, quality, or hardness, and (2) intensity, *i.e.*, quantity of rays per unit area.

The problem is complicated somewhat by the existence of two distinct types of radiation, (1) a spectrum of X-rays with a large range of wave-lengths; (2) the "characteristic" or "monochromatic" rays which are wholly characteristic of the metal of the anticathode.

The proportions of these two classes depend on the conditions of discharge, and on the material of the target. The characteristic radiations only appear when the exciting cathode rays are sufficiently fast. There is, in fact, a critical voltage for each metal, which is required in order to excite the characteristic rays, and the proportion of these rays increases rapidly as the voltage is raised above this critical limit.

METHODS OF MEASURING QUALITY OR HARDNESS.

The range of qualities of X-rays is very wide, embracing several octaves.

(1) *Wave Length.* As already remarked the hardness, or penetrating power, of an X-ray is precisely defined by its wave-length—the shorter the wave-length, the harder the ray. The most precise means of measuring the quality of X-rays is by the Crystal Spectrometer. Measurements taken by this means show that the wave-lengths of the X-rays, so far examined, lie between 10^{-7} and 10^{-9}cm.

It has been shown by the Braggs, Moseley, and others, that measurements of the diffraction of X-rays by crystals can be made to yield the wave-lengths of X-rays as well as the dimensions of the lattice-constant of the crystal concerned.

It may briefly be mentioned that in any crystal the atoms are regularly disposed in a network of intercrossing groups of planes, each of the planes in a group being parallel to and equidistant from its like neighbouring planes. The lattice constant of a crystal is the distance separating the main atomic planes parallel to some specified crystal face.

In view of their importance in X-ray measurement, we give below a table of X-ray wave-lengths for the main characteristic lines. Preceding this, is a table of lattice constants for several crystals on which extended measurements have been made.

The values of the wave-lengths of the principal lines are given below in Angström units. It should be noted that all the values rest on W. L. Bragg's estimate of the lattice constant of rock salt (see above).

(2) *Absorption Co-efficients.*

A very usual method of determining the quality of X-rays is to measure their absorption in a standard material, such as aluminium. Aluminium is commonly chosen because it is readily procurable in convenient form, and does not complicate matters by superposing a dominating characteristic radiation.

Now it is found that if all the rays, both entering and leaving a plate of material, are homogeneous (that is, wholly of the same quality), then the rays are absorbed exponentially by the plate, *i.e.*, if 1, 2, 3, ... similar sheets are successively introduced, each additional sheet absorbs the same fraction of what it receives. In other words, if there is no "scattering" or transformation of the X-rays, and if μx is the fraction of the intensity which is absorbed when the rays pass normally through a very thin screen of thickness x (cm.), then for a plate of thickness d (cms.),

$$I = I_0 . e^{-\mu d},$$

in which I_0 is the intensity of the beam when it enters, and I that of the beam when it leaves the screen. e (=2.72) is the base of the hyperbolic system of logarithms. μ is termed the linear absorption coefficient.

It follows that $\mu = \frac{2.3}{d}$ (log I_0 — log I): the logarithms are to base 10. If in a set of observations with homogeneous rays, log I is plotted as ordinate against d, the graph is a straight line, and μ is 2.3 times the slope of the line.

With ordinary heterogeneous rays, μ is greater for thin screens than for thick.

LATTICE CONSTANTS OF CRYSTALS.

Crystal.	Lattice Constant.	Observer.
	× 10^{-8} cm.	
Rock Salt, Na Cl.	2.8140	W. L. Bragg, Roy. Soc. Proc., 1913.
Calcite (cleavage face) $CaCO_3$	3.0290	Siegbahn, Phil. Mag. 1919.
Potassium ferrocyanide $K_4Fe(CN)_6 . 3H_2O$	8.408	,,
Gypsum, $CaSO_4 . 2H_2O$	7.621	,,

X-RAY SPECTRA.

Up to now, about 16 lines have been found to be associated with the characteristic X-ray spectrum of each element. Three series of lines are known at present—the K, L and M, of which the K has the highest frequency. A J series has also been claimed to exist, but the evidence needs confirmation. The K series contains at least 4 lines, α_2, α_1, β & γ of which the γ line has the highest frequency. The L series contains probably 3 groups of lines, each group similar to the K series.

and so we can only deal with an average μ, which, however, varies more and more slowly as the screen becomes thicker. (Fig. 8.)

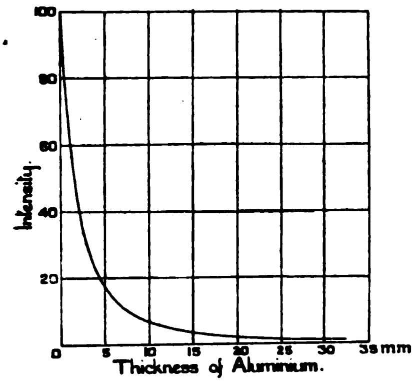

Fig. 8. Absorption curve in Al. 75,000 volts, Coolidge tube.

The logarithmic curve of absorption for heterogeneous rays, such as are given out by an ordinary X-ray bulb, is not a straight

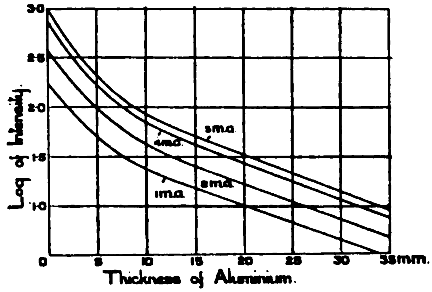

Fig. 9. Log-absorption curves in Al. 75,000 volts, Coolidge tube.

K SERIES.

At No.	Element	α_2	α_1	β_1	β_2	Observer.
		$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	
11	Na	—	11.95	—	—	Siegbahn & Stenström, P.Z., July, '16.
12	Mg	—	9.92	9.48	—	,,
13	Al	—	8.36	7.99	—	,,
14	Si	—	7.13	6.76	—	,,
15	P	—	6.17	5.81	—	,,
16	S	—	5.36	5.02	—	,,
17	Cl	—	4.7187	4.39	—	Siegbahn, P.M., June, '19.
19	K	—	3.7339	3.4474	—	,,
20	Ca	—	3.3519	3.0879	—	,,
21	Sc	—	3.0253	2.7745	—	,,
22	Ti	2.746	2.742	2.509	2.492	Siegbahn & Stenström, P.Z., July, '16.
23	V	2.502	2.498	2.281	—	,,
24	Cr	—	2.2852	2.0814	—	Siegbahn, P.M., June, '19.
25	Mn	2.093	2.093	1.902	1.892	Siegbahn & Stenström, P.Z., Feb., '16.
26	Fe	—	1.9324	1.7540	—	Siegbahn, P.M., June, '19.
27	Co	—	1.7852	1.6176	—	Siegbahn, P.M., June, '19.
28	Ni	—	1.6547	—	—	,,
29	Cu	—	1.5374	1.3895	—	,,
30	Zn	1.437	1.433	1.294	1.281	Siegbahn & Stenström, P.Z., Feb., '16.
32	Ge	1.261	1.257	1.131	1.121	,,
39	Y	—	0.833	—	—	Moseley (corrected), P.M., April, '14.
40	Zr	—	0.790	—	—	,,
41	Nb	—	0.746	—	—	,,
42	Mo	—	0.717	—	—	,,
44	Ru	—	0.635	—	—	,,
45	Rh	0.6164	0.6121	0.5453	0.5342	Duane & Hu, P.R., 1919.
46	Pd	0.589	0.583	0.516	—	Bragg.
47	Ag	0.562	0.557	0.495	—	,,
48	Cd	—	0.537	0.475	—	Siegbahn, D.P.G.V., 1916.
49	In	—	0.506	0.454	—	,,
50	Sn	—	0.486	0.432	—	,,
51	Sb	—	0.469	0.416	—	,,
52	Te	—	0.456	0.404	—	,,
53	I	—	0.437	0.388	—	,,
56	Ba	—	0.388	0.344	—	,,
74	W	0.2135	0.2089	0.1844	0.1794	Siegbahn, P.M., Nov., 1919.
92	U	—	0.15	0.10	—	,,

L SERIES.

At No.	Element.	α_2	α_1	β_1	β_2	γ_1	Observer.
		$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	
30	Zn	—	12.35	—	—	—	Friman, P.M., Nov., '16.
33	As	—	9.701	9.449	—	—	,,
35	Br	—	8.391	8.141	—	—	,,
37	Rb	—	7.335	7.091	—	—	,,
38	Sr	—	6.879	6.639	—	—	,,
39	Y	—	6.464	6.227	—	—	,,
40	Zr	—	6.083	5.851	—	5.386	,,
41	Nb	5.731	5.724	5.493	5.317	—	,,
42	Mo	5.410	5.403	5.175	—	—	,,
44	Ru	4.853	4.845	4.630	—	—	,,
45	Rh	—	4.596	4.372	—	—	,,
46	Pd	4.374	4.363	4.142	3.903	3.720	,,
47	Ag	4.156	4.146	3.929	3.698	3.515	,,
48	Cd	3.959	3.949	3.733	3.514	3.331	,,
49	In	3.774	3.766	3.550	3.335	3.160	,,
50	Sn	3.604	3.594	3.381	3.172	2.999	,,
51	Sb	3.443	3.434	3.222	3.021	2.849	,,
52	Te	3.299	3.290	3.074	2.881	2.712	,,
53	I	3.155	3.146	2.934	2.750	2.583	,,
55	Cs	2.899	2.891	2.684	2.514	2.350	,,
56	Ba	2.786	2.776	2.569	2.407	2.245	,,
57	La	2.674	2.665	2.461	2.307	2.146	,,
58	Ce	2.573	2.563	2.359	2.212	2.052	,,
59	Pr	2.472	2.462	2.259	2.120	1.958	,,
60	Nd	2.379	2.369	2.167	2.036	1.875	,,
62	Sa	2.210	2.200	2.000	1.884	1.725	,,
63	Eu	2.131	2.121	1.918	1.810	1.662	,,
64	Gd	2.054	2.043	1.844	1.744	1.597	,,
65	Tb	1.983	1.973	1.775	1.682	1.531	,,
66	Dy	1.916	1.907	1.709	1.622	1.470	,,
67	Ho	1.854	1.843	1.646	1.568	1.415	,,
68	Er	1.794	1.783	1.586	1.514	1.367	,,
70	Yb	1.681	1.670	1.474	1.414	1.267	,,
71	Lu	1.629	1.619	1.421	1.368	1.224	,,
73	Ta	1.528	1.518	1.323	1.280	1.135	Siegbahn & Friman, P.M., July, '16.
74	W	1.4845	1.4735	1.2792	1.2419	1.0955	Siegbahn, P.M., Nov., '19.
76	Os	1.398	1.388	1.194	1.167	1.021	Siegbahn & Friman, P.M., July, '16.
77	Ir	1.360	1.350	1.154	1.133	0.989	,,
78	Pt	1.323	1.313	1.120	1.101	0.958	,,
79	Au	1.283	1.271	1.080	1.065	0.922	,,
80	Hg	1.251	1.240	1.049	1.042	0.896	,,
81	Tl	1.215	1.205	1.012	1.006	0.864	,,
82	Pb	1.186	1.175	0.983	0.983	0.842	,,
83	Bi	1.153	1.144	0.950	0.954	0.810	,,
84	Po	—	1.109	0.920	—	—	,,
88	Ra	—	1.010	—	—	—	,,
90	Th	0.969	0.957	0.766	0.797	0.654	,,
92	U	0.922	0.911	0.720	0.756	0.615	,,

line, but a curve which is steeper for thin screens than for thick. (Fig. 9.) For a method of finding analytically the absorption co-efficients of the constituents of a complex beam of rays, see J. J. Thomson, Phil. Mag., December, 1915.

In the case of the characteristic radiations, an element exhibits a maximum transparency for X-rays closely approximating to its own characteristic radiations. For slightly harder rays than these, the absorption rapidly increases, the rays characteristic of the screen are produced and superposed on the transmitted rays to an extent which diminishes as the incident rays are increasingly hard-

M. SERIES.

At. No.	Element	α	β	γ	δ	Observer.
		$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	$\times 10^{-8}$ cm.	
79	Au	5.838	5.623	5.348 5.284	5.146 5.102	Siegbahn, D.P.G.V., 1916
81	Tl	5.479	5.256	—	4.826	..
82	Pb	5.303	5.095	4.91?	4.695	..
83	Bi	5.117	4.903	4.726 4.561	4.532 4.456	..
90	Th	4.139	3.941	3.812 3.678	— —	..
92	U	3.905	3.715	3.480	3.363 3.324	..

D.P.G.V., Verh. der Deutsch. Phys. Gesell.; P.M., Phil. Mag.; P.R., Phys. Rev.; P.R.S. Proc. Roy. Soc.; P.Z., Phys. Zeits.

ened. For incident rays softer than the critical type, no characteristic rays are produced. Thus, as the incident rays are gradually hardened, the transmitted rays reach a maximum intensity when the incident rays are of a quality approximating to each of the characteristic rays to turn.

A large value of μ corresponds to easily absorbed rays, and a small one to very penetrating rays. μ also varies with the nature of the absorbing screen, so that it is necessary to specify the material used. For medical purposes, it has recently been suggested that water should be chosen as the standard absorbing medium, since the absorptive power of water agrees closely with that of animal tissue.

Some workers prefer to think in terms of the thickness, D, which reduces the intensity to half value. D is connected with μ by the expression $D = 0.69/\mu$. A notion of the order of values of μ may be got from the fact that for an X-ray beam of average hardness, μ lies between 4 and 8 cm. $^{-1}$; for hard rays between 2 and 4 cm. $^{-1}$. μ for fatty tissue varies from about 0.4 for hard rays to 0.7 for medium rays.

A more fundamentally important constant is obtained by dividing the absorption co-efficient (μ) by the density (ρ) of the absorbing screen. This quantity, μ/ρ—usually called the mass-absorption co-efficient—gives a measure of the absorption per unit mass of the screen for a normally incident pencil of rays of unit cross section.

If, as was at one time supposed, the absorbing powers of different materials were truly proportional to their densities, then for the same rays μ/ρ would be a constant, no matter what the substance used as screen. In point of fact, dense substances are a good deal more absorptive, mass for mass, than light, and μ/ρ increases rapidly with the atomic weight of the screen. The increase is more noticeable with hard rays than with soft.

The accompanying table gives a series of values connecting wave-lengths and absorption co-efficients in aluminium, derived from the results of Rutherford, Bragg, Moseley, and Barkla. A scrutiny of these results shows that if μ is the absorption co-efficient and λ is the wave-length, then, when the effect of scattering has been allowed for

$$\mu = k\,\lambda^n$$

where k is a constant, and n lies between 5/2 and 3.

Wave-length, λ	μ/ρ in Al
1 × 10^{-9} cm.	0.04
2 ..	0.21
3 ..	0.57
4 ..	1.20
5 ..	2.10
6 ..	3.3
7 ..	4.8
8 ..	6.6
9 ..	8.9
10 ..	12.2
11 ..	16.5
12 ..	22
13 ..	28
14 ..	35
15 ..	43
16 ..	51
17 ..	61
18 ..	72
19 ..	83
20 ..	95
21 ..	108
22 ..	120

(3) *The speed of the Cathode Rays.*

If the exciting voltage is uniform and a magnetic field be applied to the cathode rays, the band of rays is deflected as a whole to an extent dependent on the magnetic field and the speed of the cathode rays. If the exciting voltage is pulsating, and a similar experiment be tried, a magnetic spectrum of cathode rays is formed, the least deflected band of rays corresponding to the highest speed rays which owe their velocity (v) to the maximum voltage (V) applied.

We have

$$\tfrac{1}{2}\, m\, v^2 = Ve$$

where e and m are respectively the electronic charge and mass. Substituting the accepted value of e/m

$$V = 2.8\, v^2.10^{-16}$$

where V is in volts and v is in cms. per sec.

It is thus possible, by measuring v by means of the magnetic deflection in a known field, to arrive at the value of V.

(4) *The "quantum limit" to the X rays.*

The X-ray spectrometer has brought out the truth of a remarkably simple relation between the voltage applied to an X-ray bulb and the shortest wave-length emitted. It is now well known that, no matter whether the exciting voltage is constant or pulsating, a spectrum of X-rays is generated containing a wide range of wave-lengths. This spectrum is terminated very definitely at the short-wave end (see Fig. 10), at a point determined by Planck's quantum relation

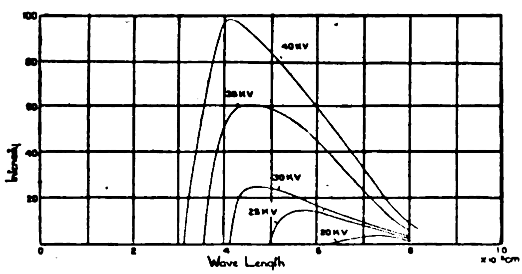

Fig. 10. X-ray spectrum of tungsten at various voltages.

$$Ve = h\nu$$

where V is the maximum voltage applied.
e is the electronic charge,
h is Planck's universal constant.
ν is the frequency of the limiting wave.

Substituting the accepted values of the constants in the above equation, we have

$$\text{Voltage} = 12{,}400/\text{wave-length in A.U.}$$

It is obvious that the X-ray spectrometer can thus be utilised in some convenient form as a means of measuring the maximum effective voltage applied to a tube.

(5) *The maximum spark-gap.*

The maximum voltage applied to a tube is most commonly measured by means of the alternative spark-gap between points or spheres. Some experience is necessary especially in the case of a gas X-ray tube, where the method tends to give too high values especially with pulsating potentials.

The work of Peek and others has shown that a spark-gap between spherical electrodes of equal size is preferable to that between points. The spark between points is now generally discredited for high voltages on account of its inconsistent dependency on atmospheric humidity and frequency of discharge. By reason of its time-lag, its readings may be largely in error in the case of high frequency steep impulses.

On the other hand, frequency and wave-shape have no appreciable effect in the case of the sphere gap, and the effects of variation in the atmospheric conditions are well known, and can be readily corrected for.

The size of the spheres is important. A good rule is not to use a gap bigger than the diameter of either of the balls, though some latitude may be permitted in this direction. The main point is to avoid the break-down discharge being preceded by brush-discharge or corona, otherwise a pulsating discharge will, in general, give gap readings which are too high. With the above precaution, a sphere gap is capable of measuring (peak) voltages from say, 10,000 volts to 500,000 with an accuracy of about 2 per cent.

The table below is based on Dr. A. Russell's formula and incorporates the latest results of the American Institute of Electrical Engineers (1918). It includes also for convenience, a column of figures for a needle point gap (No. 00 new sewing needles) which furnish a rough notion of the voltages for an instrument which is still much used. The A.I.E.E. recommend that for voltages above 70,000 (and preferably above 40,000) a sphere gap should always be employed.

The gap should not be exposed to any extraneous ionising influence, such as an arc or an adjacent spark, nor should the gap be enclosed. The first spark is the one for which the reading should be taken.

The use of a water resistance in series with the gap will prevent arcing.

Spark-Gap Voltages at 760mm. Pressure and 25°C.

Where any gap is being used outside its recommended limits, the figures are shown in brackets. The blank spaces indicate that the gap is no longer suitable. The gaps are given to three significant figures for interpolation purposes.

Correction for Density of Air

Applicable only to sphere gaps. The following table gives the relative air density under different conditions. The figures are relative to dry air at 25°C and 760mm. pressure :—(See Table B.)

Within the limits of the above table the correction factor for a sphere gap agrees substantially with the relative air density. Thus, for a given length of spark-gap, the tabulated kilovoltage in Table A must be

TABLE A.

Kilo Volts (peak)	Diameter of Spheres.						
	Needle points.		2.5 cms.	5 cms.	10 cms.	25 cms.	50 cms.
	cms. gap.	inches gap.	cms. gap.	cms. gap.	cms. gap.	cms. gap.	cms. gap.
5	(0.42)	(0.17)	(0.13)	(0.15)	(0.15)	(0.16)	(0.17)
10	(0.85)	(0.33)	0.27	0.29	0.30	0.32	0.33
15	1.30	0.51	0.42	0.44	0.46	0.48	0.50
20	1.75	0.69	0.58	0.60	0.62	0.64	0.67
25	2.20	0.87	0.76	0.77	0.78	0.81	0.84
30	2.69	1.06	0.95	0.94	0.95	0.98	1.01
35	3.20	1.26	1.17	1.12	1.12	1.15	1.18
40	3.81	1.50	1.41	1.30	1.29	1.32	1.35
45	4.49	1.77	1.68	1.50	1.47	1.49	1.52
50	5.20	2.05	2.00	1.71	1.65	1.66	1.69
60	6.81	2.68	2.82	2.17	2.02	2.01	2.04
70	8.81	3.47	(4.05)	2.68	2.42	2.37	2.39
80	(11.1)	(4.36)	—	3.26	2.84	2.74	2.75
90	(13.3)	(5.23)	—	3.94	3.28	3.11	3.10
100	(15.5)	(6.10)	—	4.77	3.75	3.49	3.46
110	(17.7)	(6.96)	—	5.79	4.25	3.88	3.83
120	(19.8)	(7.81)	—	(7.07)	4.78	4.28	4.20
130	(22.0)	(8.65)	—	—	5.35	4.69	4.57
140	(24.1)	(9.48)	—	—	5.97	5.10	4.94
150	(26.1)	(10.3)	—	—	6.64	5.52	5.32
160	(28.1)	(11.1)	—	—	7.37	5.95	5.70
170	(30.1)	(11.9)	—	—	8.16	6.39	6.09
180	(32.0)	(12.6)	—	—	9.03	6.84	6.48
190	(33.9)	(13.3)	—	—	10.0	7.30	6.88
200	(35.7)	(14.0)	—	—	11.1	7.76	7.28
210	(37.6)	(14.8)	—	—	(12.3)	8.24	7.68
220	(39.5)	(15.5)	—	—	(13.7)	8.73	8.09
230	(41.4)	(16.3)	—	—	(15.3)	9.24	8.50
240	(43.3)	(17.0)	—	—	—	9.76	8.92
250	(45.2)	(17.8)	—	—	—	10.3	9.34

TABLE B.

Temp.	Press. 720 mm.	Press. 740 mm.	Press. 760 mm.	Press. 780 mm.
0°C.	1.04	1.06	1.09	1.12
10	1.00	1.02	1.05	1.08
20	0.96	0.99	1.02	1.04
30	0.93	0.96	0.98	1.01

multiplied by the appropriate correction factor in Table B. Alternatively, to calculate the gap which will just be sparked over by some specified voltage, the voltage must first be divided by the appropriate correction factor before Table A is used.

It will be seen that under normal conditions, the correction is small or negligible.

(6) PENETROMETERS.

(*a*) *Benoist Penetrometer.* Among medical men, Benoist's radiochromometer or penetrometer, enjoys extensive use as a measurer of hardness. It consists of a thin silver disc 0.11 mm. thick, surrounded by twelve numbered aluminium sectors from 1 to 12 mms. thick. The X-rays are sent through the instrument, and the observations consist merely in matching on a fluorescent screen or photographic plate the image cast by the silver disc against the images of the aluminium plates; the thickness of the matching sector increases with the hardness of the rays. A notion of the discharge potential across a tube may be got from the very rough relation that the voltage is from 8,000 to 10,000 times the Benoist reading of the X-rays

(*b*) *Walter Penetrometer.* This consists of a number of holes in a lead disc, which are covered by a sequence of platinum discs of gradually increasing thickness.

(*c*) *Christen's Half-value Penetrometer.* Christen adopts as a definition of quality the thickness of a layer of water (or, in actual practice, bakelite), which will reduce the intensity of a beam of rays to half its original value.

The rays are sent through a stepped wedge of bakelite, alongside which is a perforated metal plate. This provides a standard of reference on a fluorescent screen, the two images being side by side. The holes in the plate are so designed that the area of the metal removed equals that which remains, so that the plate by this means reduces the intensity of a beam of rays to half-value. The holes are small enough to produce uniform illumination on a screen placed a short distance behind the plate.

(*d*) *Bauer Qualimeter.* This is a type of semi-electrostatic voltmeter, which serves to give a notion of the potential difference between the electrodes of a tube.

(*e*) *Klingelfuss Qualimeter.* This consists of an auxiliary search coil and electrostatic voltmeter. The instrument works similarly to the Bauer.

The hardness numbers of the various penetrometers are all much the same as Benoist's.

METHODS OF MEASURING INTENSITY.

The intensity of the X-rays at a particular point is defined as the energy falling on one square centimeter of a receiving surface passing through the point and placed at right angles to the surface. The question is thus on all fours with that of illumination by visible light, and the need of a unit of "candle power" in X-ray work is becoming pressing.

From the work of a number of experimenters with the X-ray spectrometer, the total energy emitted by an X-ray bulb may be written

$$E = k N i V^2$$

where V is the voltage on the tube,
i is the current through the tube,
N is the atomic number of the target,
k is a constant.

The value of k will depend on whether a gas or a hot-cathode tube is employed, and also on the type of exciting potential. The above expression refers only to the independent or "white" X radiation. If the voltage is such as to excite the characteristic radiations, the voltage comes in as a higher-powered term than V^2, and the efficiency increases.

Measurements of the value of k have been made and result in showing, unfortunately, that the efficiency of an X-ray bulb is deplorably small, of the order of 1 part in 1000. The chances that a cathode ray will ultimately come into suitable conflict with some atom and so generate an X-ray are slight. We raise those chances by increasing either the exciting voltage or the mass of the atom of the target.

The X-ray emission is virtually distributed over a sphere, or, more practically, over a hemisphere since the target blocks out most of one half of the sphere of radiation.

Thus the intensity (comprising all wavelengths) falling on a square centimetre at distance d from the anti-cathode may be written

$$\frac{k N i V^2}{d^2}$$

If the length of exposure is t secs. the expression becomes

$$\frac{k N i V^2 t}{d^2}$$

It is apparent that we can base on this relation a system of X-ray intensities and doses, provided we can measure i and V and be certain to what extent each is effective in generating rays which are of practical utility.

In practice we almost always filter out the long waves and we shall need then to know the new value of k, so as to correct for the proportion of i which is not usefully employed.

The measurement of all the terms in the above expression, except perhaps i and V, offers no difficulty. i can be measured by a milliammeter of suitable design which even with rapidly pulsating currents appears to indicate the mean current, as has been verified by the use of the voltameter and oscillograph.

The measurement of V has already been referred to above. If the exciting potential is constant, it can be measured by a resistance type of voltmeter in series with a high resistance. If the potential is fluctuating, recourse will usually be had to the sphere spark gap. The voltages are mostly too high for an electrostatic voltmeter.

In addition to the above method, the radiologist has employed a variety of means of measuring the intensity of X-rays at some selected point in the beam. To this end one or other of the properties of the rays have been utilised—heating, ionising, photographic, fluorescing, or chemical.

The heating effects are minute, and the method is only fitted for the research laboratory.

(1) *Ionisation methods.*

When X-rays pass through a gas they impart to it a temporary electrical conductivity, the extent of which depends on the number of ions formed, and thus on the amount of energy absorbed in the gas. An ionisation method of evaluating X-rays thus resolves itself into the measurement of a minute electric current. For this purpose an electroscope or electrometer is commonly employed, and the delicacy and convenience are such that the method has found almost universal acceptance among research workers.

But in practical radiology the method is only beginning to find favour, more especially in deep therapy. The iontoquantimeter of Szilard was one of the first instruments to be designed on this basis. In its most recent development a part of the quantimeter is sometimes actually introduced into the affected organ, and the rays measured are those which are actually received at the point concerned.

The ionisation method is unapproached in sensitiveness by any other method; it does not depend dominantly upon any selective process, and it is reasonable to anticipate that some unit of dosage thus developed (and connected perhaps with the accepted radium standard), will ultimately receive recognition as a standard.

(2) *Photographic and Fluorescence Methods.*

Photographic plates record only about 1% of the energy of the X-rays passing through them, but, nevertheless, a method of measuring intensity by this means has been developed and finds favour with some workers.

As is the case with most types of intensity meters, the short-waved rays are recorded disadvantageously compared with the soft rays. Furthermore, a photographic film betrays marked selective absorption, and the photographic effect may be quite misleading in consequence.

To the worker with limited resources the photographic method of measuring intensity offers advantages because of its simplicity. Some form of opacity-meter for obtaining a measure of the density of the image is the chief requirement. The opacity meter measures the extent to which a standard beam of light is cut down by the photographic film whose density is required. If I_0 is the intensity of the testing light which is incident on the developed film, and I_t that of the transmitted light, then, if μx is the fraction of the energy which is absorbed by a very small thickness, x, of the film,

$$I_t = I_0 e^{-\mu d},$$

where d is the thickness of the film. The film is assumed to be equally dense throughout its thickness.

For films of uniform thickness, d is constant, so that μ is proportional to log (I_0/I_t). μ is called the absorption co-efficient; (I_0/I_t) is known as the opacity, and equals the number of times the incident light is cut down. Log (I_0/I_t) is termed the opacity-logarithm. The transparency is the reciprocal of the opacity. Now, by definition, μ is proportional to the density of the image, *i.e.*, to the amount of silver per unit area of film. Thus the ratio of two opacity-logarithms gives the ratio of the film

densities, and therefore, the ratio of the photographic energies in the two cases. The opacity meter is graduated to read directly in opacity-logarithms.

In fluorescence methods the luminosity is matched against some standard fluorescence excited by a steady source of radiation, such as radium. The drawback to such methods is that the fluorescing salt becomes "tired" under the action of the rays. The sensitivity of a screen may also vary considerably from point to point, so that it is difficult to make a fair comparison. Barium platinocyanide is the material commonly used to sensitise a fluorescent screen. This salt, which has the formula $BaPt(CN)_4$, $4H_2O$ exists in three different forms, of which the green crystalline variety is by far the most efficient for fluorescing purposes.

(3) *Chemical and other Methods.*

In the therapeutic use of X-rays, various chemical reactions brought about by the rays have been suggested, and employed, from time to time as aids to "dosage"; for example, the discolouring of various alkaline salts (Holzknecht, 1902); the liberation of iodine from a 2 per cent. solution of iodoform in chloroform (Freund, 1905; Bordier and Galimard, 1906); the darkening of photographic paper (Kienböck); the precipitation of calomel from a mixture of mercuric chloride and ammonium oxalate solutions (Schwarz, 1907); and the change of colour of pastilles of compressed barium platinocyanide (Sabouraud-Noiré and Bordier). X-rays resemble light in their property of lowering the electrical resistance of selenium; this property, if the pronounced fatiguing of the selenium could be overcome, would, doubtless, furnish the basis of a very convenient method of measurement, though Fürstenau, in his intensimeter, claims to have got over this difficulty. It must be admitted that most of these methods provide little more than the roughest notion of the intensity of a beam of ordinary heterogeneous X-rays.

Of all the various intensity-measurers, the pastille finds most favour with medical men. The barium-platinocyanide discs are some 5 mms. in diameter, and their colour, initially a bright green, changes, when exposed to the rays, to a pale yellow, and finally to a deep orange. The pastille is placed at a specified distance from the anticathode of the bulb, and the colour is matched against one of a number of standard tints. The method is easy in practice, and is fairly reliable as a guide for short exposures, but it is not trustworthy for heavily filtered or very penetrating rays. The pastille method is defective in that it attempts to measure rays of all qualities by a surface coloration. Other platinocyanides show similar colour changes when exposed to X-rays. Levy has shown that the change of colour is due to a change from the crystalline to the amorphous condition. If the pastille is put aside, the reverse change slowly takes place, especially in the presence of light, so that the pastille should not be exposed to full daylight during the X-ray treatment. Ultra-violet light and radium rays cause similar browning in such pastilles.

The following table gives an idea of the relation between the different dosemeter scales:—

5H units	(Holzknecht; alkaline salt)
= Tint B	(Sabouraud-Noiré; pastille)
= Tint 1	(Bordier; varnished pastille)
= 3 to 4I	(Bordier and Galimard; iodine solution)
= 10X units	(Kienböck; photographic plate)
= 3.5 Kaloms	(Schwarz; mercury solution)
= Villard dose.	

Effect of Potential Wave Form.

So long as radiologists confined their measurements on the X-ray bulb to the milliammeter and the point gap, little progress was made in the subject of the best form of exciting potential wave. It was realised that the millammeter was often misleading if used alone, but insight into the problem only came with the use of the X-ray spectrometer and the oscillograph.

The oscillograph (preferably of the cathode ray type) should be arranged to give simultaneous graphs of both potential and current wave forms in the X-ray tube. The spectrometer analyses the resulting X-ray output and shows the distribution of intensity among the various wave lengths.

Work such as this has shown the truth of what might have been anticipated on à priori grounds, *i.e.*, the importance in pulsating discharges of keeping the conditions so that the potential and current waves are in phase. In other words, for efficient output of X-rays as much of the current as possible should be sent through

the tube with the maximum potential actuating it.

As the output of X-rays depends on the square of the voltage, the ideal state of things would appear to be to rush the potential as quickly as possible to the maximum and keep it there for as long as any current is passing. Voltages lower than the maximum are less efficient.

In practice much depends on the type of X-ray bulb used—whether gas or hot cathode, and it will be instructive to compare the behaviour of three main types of exciting potentials (*a*) constant potential (*b*) sinusoidal transformer discharge (*c*) sharp-peaked pulsating coil discharge, all running under the same maximum voltage and the same milliamperage.

First take the case of the Coolidge tube. Owing to the existence of the saturation current, the shape and limits of the current curve are greatly dependent on the characteristics of the potential wave. With constant potential, the current remains constant at its saturation value (Fig. 11).

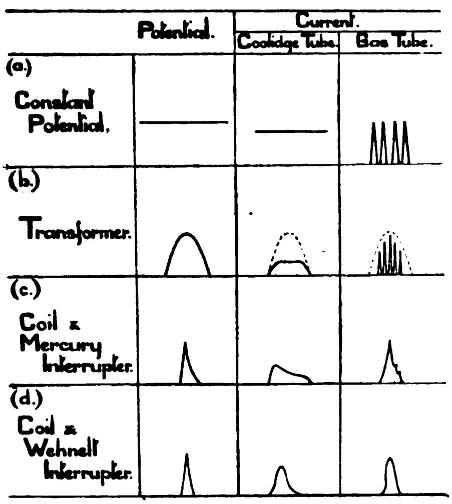

Fig. 11.

In the case of the transformer loop the current rises gradually to its saturation value and dies away again as the potential loop terminates. In the case of the coil and interrupter, the current again rises to its saturation value, but as a whole the current curve is prone to lag behind the potential curve. The defect, which is due to arcing within the interrupter, increases as the current through the tube is increased. This is the explanation of the well-known fact that, as the current is raised, the output of X-rays increases only slowly and by no means proportionately. A partial cure is to raise the speed of interruption, as in the Wehnelt break.

We are led to anticipate the results of the spectrometer curves. Remembering that the area of each curve is a measure of the total output of radiation (of all wave lengths), we see from Fig. 12 (derived from

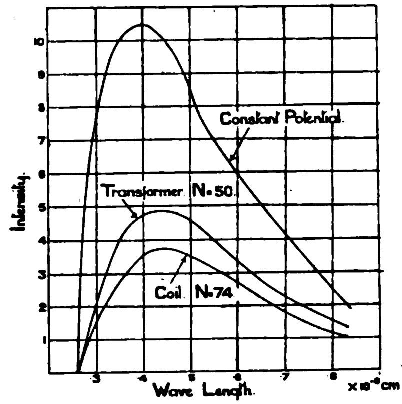

Fig. 12. Coolidge tube excited by various generators. 46,000 volts, 1 m.a. unfiltered.

Dauvillier) that the constant potential is the most efficient, then the transformer and lastly the coil. Furthermore, the crest of the curve is of slightly shorter wave length in the case of the constant potential. It may be added that the superiority of the constant potential becomes less marked as the potential rises.

If we now consider the case of the gas tube, the current-curves (Fig. 11) prove, in most circumstances, to be quite different from those for the Coolidge tube. The current-curve now exhibits no saturation value, but consists instead of a succession of peaks, no matter whether the exciting potential is constant or varying. The constant potential produces, so to speak, all the effects of an intermittent one. In the case of the transformer, the middle portion of the potential loop produces a number of current-peaks whose heights wax and wane with the potential. The coil produces one or more current-peaks corresponding to each potential-peak. We are led to infer that the spectral curves for the different excitants will not differ appreciably and this proves to be the case. (Fig. 13; Dauvillier). Further, the maxima of the several spectral curves all agree in wave

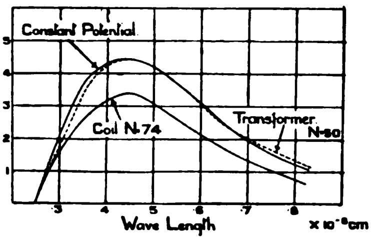

Fig. 13. Gas tube excited by various generators. 48,000 volts, 1 m.a. unfiltered.

length. We realise then that the shape and limits of the spectral curve are determined mainly by the tube rather than by the excitant.

In the case of both gas and hot cathode tubes there is a variety of factors which may modify the various curves and graphs appreciably in detail, without affecting the main outlines.

To sum up, we may conclude that for maximum efficiency in the case of a Coolidge tube we should raise the potential on the tube as high as is expedient or possible and keep it there. Thus the ideal excitant would appear to be constant potential or, failing that, a transformer of high frequency.

The "shock tactics" of a coil, which are largely wasted on a Coolidge tube, are doubtless well adapted to a gas tube owing to its characteristic way of breaking down under potential stress. From a practical point of view, the transformer potential wave is probably not quite so well suited to a gas tube, but constant potential should prove very effective apart from difficulties of generation, etc. The practical difficulties of obtaining an equally high constant potential or maximum transformer voltage (selectively rectified) are probably greater, but otherwise they would seem to offer equal advantages.

The interval between the discharges of a coil-driven bulb is not without its advantage in helping to keep down the temperature rise of the target. But with a mercury break under ordinary conditions, this interval amounts to about 90% of the time between successive impulses, and is needlessly long. In the case of a single phase transformer, the corresponding figure is of the order of 60%.

We can raise the efficiency of the coil or transformer by increasing the frequency substantially, and so crowding in more impulses per second, though the increased heating of the target may have to be met.

If, further, in the case of a coil, we raise the voltage on the primary and increase the capacity of the condenser we can produce a series of flat-topped peaks with little or none of the "tail" in evidence. We are thus approximating more and more to the transformer (selectively rectified), and, in the limit, the ideal steady potential. During these changes, the readings of the milliammeter will approach more and more the effective values from an X-ray point of view

Constant Potential.

The value of constant potential has been referred to. It is not only an efficient means of generating X-rays, but it permits precise measurement. As already remarked, the superiority of constant over varying potential is less marked as the voltage is increased, except when the characteristic radiations begin to be generated when the constant potential increases its relative effectiveness. Moreover, constant potential is admirable in its precision for therapeutic purposes. In radiography it generates sufficient diversity of wave-lengths to give good contrast and detail.

Those workers who have used the influence machines in America and elsewhere speak highly of the results. There is a future for a static machine of engineering design and large output, which will defy the varying and generous humidity of this country.

The only other means of obtaining steady potential are by use of the transformer,

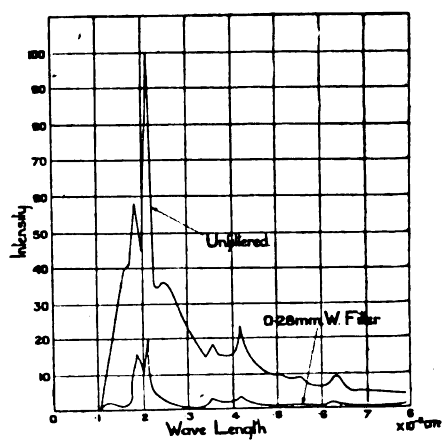

Fig. 14. X-ray Spectrum of Tungsten showing intensity distribution at 110,000 volts, unfiltered and filtered by tungsten plate.

together with the kenetron or hot-cathode valve. These latter can now be obtained to rectify 200,000 volts. By the use of 3 phase current and 6 kenetrons, a voltage fluctuating only 15% can be obtained. There are a variety of ways of combining kenetrons with condensers and inductances, so that the variation in the resulting potential is trifling. For example, Hull, of the G.E.C. Laboratory at Schenectady, has so transformed and rectified 150 volts A.C. (∼ = 2000) to 92,000 (Fig. 14), with a fluctuation of about 1% (Fig. 15); or 50,000 volts with a fluctuation of only 0·1%.

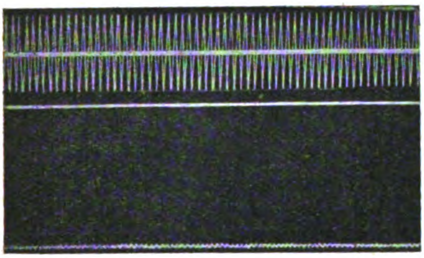

Fig. 15. Upper curve A.C. Lower curve, rectified high tension.

Homogeneous X-Rays.

An ideal of the radiologist has always been a means of producing homogeneous X-rays, so that, among other things, a precision dose can be the better formulated in therapy. While all X-ray beams are heterogeneous, they tend to become less so as the voltage is raised and the rays are filtered by the right choice of substance of a suitable thickness. This may be seen either from absorption curves or, more accurately, from spectral distribution curves.

But the nearest approach to homogeneity can be reached by operating the X-ray bulb at a voltage somewhat above one of the critical values necessary to generate one of the three known characteristic radiations (K, L, M) of the anticathode, and then filtering by a screen either of the same element as the anticathode or, preferably, by an element of slightly smaller atomic number. We have already remarked that above the critical voltage the characteristic radiations are generated more copiously than the general radiation. The voltage should not be too high, however, or short-wave general radiation will begin to make its appearance, and will not be removed by filtration. There is, in fact, an optimum voltage. For example, while the critical voltage for the K radiation of tungsten (At. No. = 74) is about 70,000 volts, the optimum voltage is about 100,000 volts. A filter of tungsten (Fig. 16, Hull) or tan-

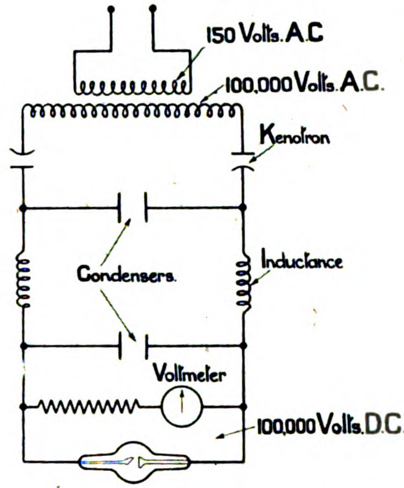

Fig. 16. Rectification of A.C. to steady high voltage (Hull).

talum (At. No. = 73), 0.15 mm. thick, removes most of the general radiation, but leaves both the β and α components of the K radiation. An equally thick filter of ytterbium (At. No. = 70) would leave only the α component, with an intensity at least 30 times that of the remaining general radiation. Similarly for molybdenum (At. No. = 42) the optimum voltage is about 30,000, and the best filter zirconium (At. No. = 40). Tungsten would be a good filter for platinum radiation (At. No. = 78).

At the National Physical Laboratory there is a battery of X-ray tubes each with a different anticathode so that a variety of homogeneous rays can be obtained. Unfortunately, such beams are of feeble intensity for radiological purposes.

INDUSTRIES AND LABOUR IN INDIA.

The second part of Volume I of the "Journal of Indian Industries and Labour"* contains much that is of interest. Sir Thomas Holland contributes an article on the principles which govern the grant of mineral concessions in India. His discussion of the grounds on which the mineral policy of a government has to be

*Journal of Indian Industries and Labour. Volume 1. Part 2. Calcutta. Superintendent, Government Printing, India. Price Rs. 1-8-0 per part or Rs. 4-8-0 per volume of four parts.

determined explains the reasons for restrictions which are apt sometimes to appear unnecessarily irksome to those engaged in the development of the mineral resources of a country. The article concludes with a very useful summary of the rules for the grant of prospecting licences and mining leases which are at present in force in British India.

A useful account of the Rajputana salt industry, with particular reference to the salt works on the Sambhar Lake, is given by Mr. P. C. Scott O'Connor, an officer of the Northern India Salt Revenue Department, who has studied the history of Government control over salt production and has had considerable personal experience of the actual work of producing salt for the market.

Mr. J. W. Meares, in an article entitled "The Hydro-Electric Survey of India," explains in a lucid manner the potentialities of India in the matter of sources of water power. He discusses the various methods by which water can be harnessed in order to produce power for the development of industries and the provision of public conveniences without interfering with its function of irrigation. An account is given of the origin of the hydro-electric survey of India, of its results up to date, and of the limits within which its work is confined. Mr. Meares' remarks on the proper utilization of electricity will be of use to those who have to weigh the comparative advantages of this and other sources of power.

Mr. Clow contributes a thoughtful article on the subject of "Factory Children and Education." The history of legislation relating to the various restrictions on the employment of children in factories is given, and the comparative merits of the two schools of thought, one of which favours the prescription of educational tests before employment, and the other the putting of compulsion on employers to provide education during the period of employment in a factory, provides a helpful contribution to the discussion of this difficult subject.

The subject of "The Hide, Skin and Leather Trades and Boot and Shoe Manufacturing in India," is treated by Sir Henry Ledgard, who was until recently the Honorary Adviser to the Government of India on Boot Production, and who, in 1918, read a valuable paper before the Royal Society of Arts on "The Indian Hide and Leather Trade." A detailed account is given of the methods introduced into the manufacture of boots for the Army in India during Sir Henry Ledgard's short term of office. The article concludes with a summary of the position of the leather and boot industries in India at the present time.

An address on the subject of chemical research for the development of industries in India, which was read by Dr. E. R. Watson at the last meeting of the Indian Science Congress, is reproduced as an article in the Journal. Dr. Watson pays particular attention to the possibilities of producing in India the essential munitions of war which he claims should be the foremost consideration in the industrial policy of the country.

An outline of the present position of technical and industrial education in Bengal is given in a short article by Mr. W. H. Everett.

Other items of interest are a summary of information regarding industrial disputes in India during the first quarter of the year, miscellaneous notes on various subjects, including the bleaching of shellac, the investigation of cotton stalks as a paper-making material, three short notes on subjects of industrial interest contributed by Sir Alfred Chatterton, and a statement showing the kind, quantity and cost of stores purchased in India by Government during the three official years ending 1919-20. A new feature of the Journal is the publication of reviews of recent publications.

A notice announces that eight bulletins of Indian Industries and Labour have now been published and that seven more are in press.

GENERAL NOTES

GREAT CITIES OF THE WORLD.—The Garden Cities and Town Planning Association have arranged to hold a first series of illustrated lectures on the Great Cities of the World, at King's College, Strand. Professor Patrick Geddes will deliver the first on "The City of Jerusalem," on Thursday, October 13th; Dr. H. P. Berlage, President of the Dutch Society of Architects, will deliver the second on "Amsterdam—Past and Present," on Thursday, November 10th; and a third, on "The City of Milan," will be given on Thursday, December 8th. The hour in each case is 5.30 p.m. Particulars of the course may be obtained from the Secretary, Garden Cities and Town Planning Association, 3, Gray's Inn Place, W.C. 1.

REVENUE OF THEATRES AND PLACES OF AMUSEMENT IN PARIS.—Under the title of "Le budget des Plaisirs," a Paris journal gives the following figures showing the receipts of the theatres and other places of amusement in Paris for the last four years from 1917 to 1920 inclusive, as follows:—1917, 82,037,000 francs; 1918, 80,219 000; 1919, 148,471,000; 1920, 219,455,000. During the same period, the subventioned theatres increased from 6,761,000 francs to 22,787,000 francs; theatres without subvention from 20,221,000 francs, to 64,486,000 francs. The Café concerts from 9,762,000 to 25,601,000 francs; music halls from 6,463,000 francs to 19,958,000 francs; circuses, skating rinks, dancing places, from 1,888,000 francs to 26,230,000 francs. Finally, the receipts of the cinemas increased from 17,378,000 francs in 1917 to 68,776,000 in 1920.

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FRIDAY, OCTOBER 7, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURE.

X-RAYS AND THEIR INDUSTRIAL APPLICATIONS.

By Major G. W. C. Kaye, O.B.E., M A., D.Sc.

Lecture III.—*Delivered March 21st*, 1921.

X-Rays and Medicine.

Radiography.

X-rays have become one of the handmaidens of medicine, a fact which is bound up with the great improvements of recent years in X-ray equipment and technique which have given the diagnostic methods of physicians and surgeons a facility and exactness never dreamt of at one time. Exposures have been enormously shortened, and snapshots of any part of the body can now be taken.

In surgery of the bone, not only fractures, but the intimate lamellar structure of the bone can be examined; we have, moreover, learned that tumours and cysts in bones are not specially rare and that nearly all sprains are accompanied by slight fractures of the bone. When a bone is badly splintered, the dead bone splinters can be sorted out from the living.

Tumours in any part of the head can be detected and their position determined. The diagnosis of diseases of all parts of the alimentary canal is routine—stricture of the oesophagus, stomachic disorders, diseases of the appendix and colon, etc., can all be demonstrated by the X-rays with the assistance of special food containing matter opaque to the rays.

Stones in the kidney and (more recently) the gall bladder, diseases of the liver and pelvic organs, incipient tuberculosis in the lungs and joints can be diagnosed with certainty and without pain or danger.

Dental radiography has become an important subject. By suitably disposing a photographic film radiographs of individual teeth can be obtained, revealing in perfect fashion the condition of both the tooth and surrounding bone.

During the war, many thousands of radiologists helped to build up the triumphs which X-rays achieved. The X-ray became as indispensable as the dressing or the splint, and it was an essential adjunct in prescribing and directing as well as avoiding operations. The detection of bullets and shell fragments in any part of the body was commonplace, and the X-rays were also used to guide the surgeon during his actual efforts to remove foreign bodies. Cleverly designed X-ray motor-lorries permitted early examination in the field. In the case of eye wounds, X-ray stereoscopy attains its fullest delicacy, and the location of small foreign bodies can be carried out to the hundredth part of an inch. Another war development of radiology was its employment by the orthopædic surgeon in his efforts to restore damaged limbs. Many hundreds of thousands of radiographs were taken at the various hospitals during the war.

In another direction, the venous and arterial systems of the human body can, by the aid of suitable injections be radiographed and displayed to the student.

H. Béclère has done excellent work in the production of X-ray finger prints. For the purpose, the finger tip is rubbed with red lead, and the resulting radiograph is peculiar to the patient, not only in the design of the finger print, but also in the shape of the bone.

Radiotherapy.

The X-rays possess valuable properties in the treatment of malignant disease. The living cells have the power of resisting

or responding to X-rays while malignant cells disappear with suitable "dosage." The method has, for example, been largely and successfully employed for rodent ulcers, and much attention is being paid to the treatment of cancer.

In many skin diseases, the X-rays have proved to be of notable service. For example, they are now the accepted and certain means of curing ringworm. The "dose" is all important, for the sweat glands and hair follicles are also affected and, with excessive exposure, may even be destroyed, the result being baldness.

The corpuscles of the blood are prejudicially affected by X-rays, resulting in a form of aplastic anaemia. Curiously enough, the rays seem to have little or no action on bacteria or their spores, and in this respect stand out in marked contrast to ultra-violet light.

Deep-seated organs are now successfully treated by X-rays. In deep radiotherapy German technique is tending in the direction of administering massive doses of X-rays in the shortest possible time, always having regard to the safety of the overlying skin. In other words, "shock tactics" are used, and the wave form of the exciting potential may prove to be important in this connection. The soft rays are removed by using metal filters (Al or Zn), with a coating on the side nearest the skin of wood or leather, so that no characteristic radiation may play on the skin. Over-dosage of the skin is also avoided by employing multiple parts of entry, each of the various beams being properly directed at the deep affected tissue.

The chief hindrance to precise radiotherapy at the present time is probably the lack of a means of measuring the dose of radiation absorbed by the particular region concerned, especially if it be at a depth in the body. On physical grounds, at any rate, it would seem that it is only those rays which are absorbed that can produce physiological changes, and only such rays should be included when speaking of a dose. It may be, of course, that selective action is present, and that only a restricted range of wave-lengths is appropriate for the conversion of energy in the correct spot. With this reservation it would seem that the degree of reaction should be a function of the absorbed and converted energy. The problem is complicated by the lack of homogeneity of the primary beam.

Among the tragedies of the war few were more pathetic than the ghastly disfigurements caused by shell wounds of the face and head. Fortunately, it was often possible, by the wonderful grafting operations of the surgeon, to restore at least a semblance of the patient's former appearance. Lips were renewed, new noses built up, eyelids replaced, cavities in the palate filled in by flaps taken from the skin or scalp. The scar-tissues and flaps were kept pliant and adaptable by "spraying" with X-rays, which also served to depilate hair and to stimulate the healing process in both flaps and bone.

The Examination of Materials.

In well nigh every branch of industry the testing of materials has come to be of importance. With increasing knowledge and the stress of competition, a variety of testing methods have been evolved to ascertain quality and uniformity as determined by the several physical, chemical and visual characteristics. Such tests are commonly conducted on samples which are selected to be as representative as possible. From the nature of things, the value of the results is limited, and the engineer in particular is ever on the look-out for opportunities for greater insight into the materials he employs.

The employment of X-rays in the examination of materials, lies at present in two main directions:—

(1) X-ray crystallography or the study of crystal structure.

(2) Radiography or X-ray shadow photography.

(1) X-*Ray Crystallography.*

Time forbids more than a reference to the great potentialities of the results of X-ray spectrometric analysis as applied to crystal structure. It is a matter of great satisfaction to Englishmen to know how much the subject owes to Sir William Bragg and his son, whose published work on the subject is of the highest fascination and importance. Several methods have been employed. As mentioned above Laue, at Munich, in 1912 sent a heterogeneous beam of X-rays through a thin crystal and photographically showed that a diffraction pattern was produced. The Braggs followed with the X-ray spectrometer, in which monochromatic X-rays are reflected from the several faces of a crystal, and by that means pro-

ceeded to disclose the atomic architecture of a large number of crystals, and the lines of the emission spectra of many elements.

The practical possibilities were greatly enlarged when Debye and Scherrer (at Zürich), and Hull (at the G.E.C. Research Laboratory, Schenectady) showed that large crystals were not essential, but that the method could be applied to an aggregate of finely powdered crystalline material, provided the orientation were sufficiently random. This was a big step forward, for it enables the crystalline structure of a body to be examined even when the individual crystals are microscopic or ultra-microscopic in size. We now know that almost every solid substance betrays crystalline structure, and it would seem that the various physical properties—elasticity, hardness, melting points, etc., are all manifestations of the various atomic forces which reveal themselves in the crystalline form. The very formation of solids may be merely an outward and visible sign of crystallisation, and a definition of a "solid" may be so derived which is, at any rate, as adequate as others which have been framed. Not only the growth, but the decay, the change points, etc., can all be followed and watched without harming the body in any way.

We have thus a new tool of research, which, although at present rather delicate and tentative in application, would seem to offer unusual possibilities. The metallurgist, to whom crystalline formation means so much, need no longer have to content himself with inferring from their external forms what the internal structure of the crystals in his metals and alloys may be. He may also find that the method will throw light on the fundamental nature of the effect of heat-treatment, tempering, rolling and ageing on crystalline metals and alloys.

It has been shown that amorphous carbon really consists of minute graphite crystals; colloidal gold and silver are made up of minute, yet perfect, crystals so small that they contain only a few score atoms. Even the particles "sputtered" from a cathode in a discharge tube are possible of examination, and are found to be crystalline.

These are but a few of many examples. There is a great opportunity for the metallurgist and physicist to get together. At present, the main difficulties are those of technique. Monochromatic X-rays have at present to be used, and as these can be obtained only of feeble intensity, protracted exposures have hitherto been necessary, though these can now be greatly shortened by the use of more sensitive plates.

(2) *Industrial Radiography.*

As was anticipated by Röntgen and others, when the art of radiography had sufficiently advanced in medicine, it extended its scope to industry. As already remarked, the method of X-ray inspection has the advantage of not injuring a body in any way. Furthermore, it provides in many cases the only means of detecting concealed defects in a material, or of scrutinising in a structure the accuracy of assembly of component parts which are hidden from view.

The development of industrial radiology has been bound up with that of the Coolidge tube, and both during and since the War the X-rays have been applied to a variety of branches of industry. As already explained, the method depends on receiving the shadow of the object on a fluorescent screen or photographic plate, and it should be made clear at the outset that a radiograph shows only the gross structure of a material, and gives no information as to the crystalline or microscopic structure from point to point.

While the general technique is much the same as in medicine, mention should be made of one of the chief experimental precautions in the X-ray photography of metals. Even in medical radiography the experienced worker is well aware of the effect of the scattered radiation which is generated whenever a beam of X-rays strikes any particle of matter. Such scattered radiation, if allowed to reach the

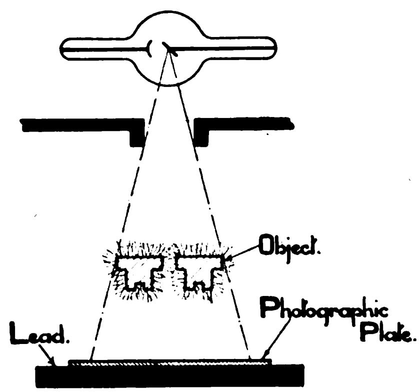


FIG. 17.

photographic plate, tends to fog the main image. The various surfaces of the bodies encountered are the chief offenders and even the air contributes its quotum.

The effect is especially marked with metallic objects which require relatively long exposures ; worthless results will be obtained in the absence of suitable precautions. These consist in enveloping the photographic plate, back and front, with sheet lead (preferably with an inner lining of aluminium), a hole being left no bigger than necessary for the reception of the direct image of the object. If the object is continuous and flat, there is no difficulty, for it can be brought into close contact with the plate. If, however, the body is irregular in contour, it may conveniently be cemented with paraffin wax to the bottom of a cardboard or aluminium tray, and mercury, fine lead shot or the like poured round it. Wax filling is also necessary, both to fill up any pockets or cavities and to prevent the mercury or shot from straying into the path of the projected image.

Considerable gain may result from the use of the Bucky grid between the object and the plate. This consists of a rectangular metal grid, the faces being spherical in contour and the dividing cell-walls of the grid everywhere radial. The grid, while allowing direct X-rays from the focus to pass, kills the majority of the scattered radiation. The grid is kept in slight motion to prevent it being registered on the photograph.

Naturally the orientation of the object with reference to the beam of X-rays may make or mar a radiograph. Distortion may be reduced by avoiding undue obliquity of the rays, and to this end it is wise to keep the distance between the object and bulb as great as is expedient. For good definition the rays should be stopped down as much as possible.

The present practicable depths which can be penetrated in various materials are :—

4 to 5 mm. of lead.
12 mm. of tin.
7.5 cms. of steel (carbon) or iron.
10-15 cms. of aluminium and its alloys.
30-40 cms. of wood.

The limiting factor in practice is the exposure which hitherto has been very protracted with the greater thicknesses. However, with the latest type of X-ray plate, the exposures are greatly reduced, and 1 inch of steel, for example, now requires an exposure of rather less than a minute, using a voltage of about 130,000 and a few milliamperes through the tube.

Within the above limits we can, with considerable delicacy, hunt out anything which is so disposed as to cast a measurable variation in the shadow, provided the body is not too complicated in design to render the shadow too confusing to interpret. The method is surprisingly sensitive, for example, tool marks and fine mould marks often show up in a radiograph. The opacity is merely a measure of the number and weight of the atoms encountered, and so different qualities of a metal possessing different densities display different intensities in a radiograph, *e.g.*, a wrought rivet in a casting of the same metal shows a darker image. For the same reason, equal thicknesses of carbon, nickel and tungsten steels differ markedly in transparency, a property which has been turned to account.

Electric and oxy-acetylene welding have come into great prominence during and since the War ; an indifferent welder can turn out what appears, on the surface, to be an excellent weld, but is quite an unreliable job notwithstanding. There appears to be no adequate mechanical test for a weld, and in any event any such test,

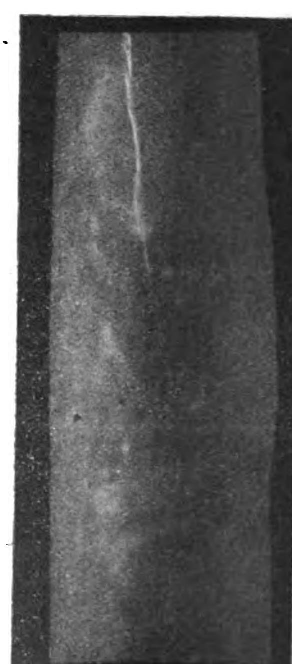


FIG. 18.—Defective Weld in ½in. Steel Plate.

whether mechanical or microscopical, destroys the weld, good or bad. The X-rays promise to be of great use in this connection. If the component parts are not actually fused together, a narrow dividing line comes out on the plate. (Fig. 18.) Blisters and blowholes show up as light spots. X-ray photography of welds up to 1 inch thick is now quick, easy and certain; with modern equipment, lengths up to 2 feet can be taken at once, the exposure being a fraction of a minute. The amount of detail revealed is extraordinary, and the process compares favourably with that of photomicrography which is only very local in its test, and, as already remarked, involves the destruction of the weld. The X-ray method has proved to be a somewhat severe critic of present day welds as commonly carried out.

Hidden cracks in a metal, which are a bugbear to metallurgists, can often be detected, though if they are very fine or tortuous (hair cracks) the method is rarely suitable. Such cracks are sometimes the sequel to "pipes" or blowholes in the ingot, and it is easier to detect them in the ingot than after working.

In the case of alloys, the uneven distribution of any component results in a "patchy" or streaky radiograph. X-ray examination will often diagnose defective soldering or brazing, the substitution of one metal by another, hidden stopping or pinning and so on. The method has also found application in detecting hidden corrosion (as in gas cylinders, in ferro-concrete and the armouring of cables) in scrutinizing steel turbine discs for segregations, etc., and so on.

Naturally enough the X-rays found a great opening during the War in the manufacture of explosives and related devices. In some instances, *e.g.*, the correct filling of liquid-gas grenades, the examination of opaque cordite, the interior detail of detonators, Stokes igniters, vent-sealing tubes and other pyrotechnic stores, no other method of inspection was possible. The X-rays also proved of value in examining enemy ammunition of unknown design, where, for reasons of safety, it was desirable to ascertain the internal construction before opening up. Most of this work was carried out by the Research Department at the Royal Arsenal, Woolwich.

In the case of timber, the different varieties absorb X-rays to different degrees. Peculiarities in the structure and path of the fibres (such as the contortions which produce "figure") are easily discerned. The denser heart wood is differentiated from the sap wood, the summer and spring growths of the annual rings are readily identified, and defects such as knots or grub holes show up with astonishing clearness.

A method of utilising the X-rays to examine the wooden parts of aircraft was developed by Kaye and Knox on behalf of the Air Ministry during the war. At a time when the submarine was seriously endangering the country's supplies of high grade timber, from Canada and the States, designs for building up aeroplane parts from smaller timber were developed, using laminated or "box" structures. The workmanship required has to be of the finest, and much of it is hidden of necessity, but the Inspector now has a powerful ally in the X-rays which unerringly reveal

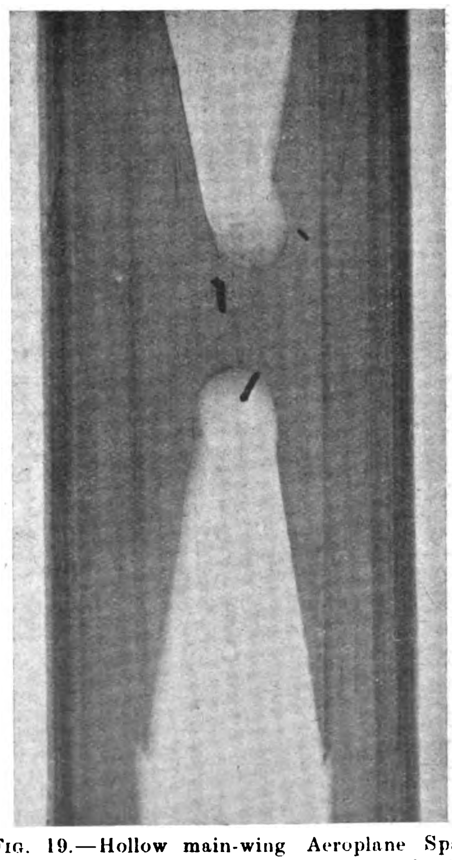


FIG. 19.—Hollow main-wing Aeroplane Spar. Poor workmanship in internal strengthening block.

hidden faults such as knots, large resin-pockets, defective glueing and poor workmanship. (Figs. 19 and 20.) Wood is very transparent to X-rays, and thicknesses up to 18 inches or more can be dealt with,

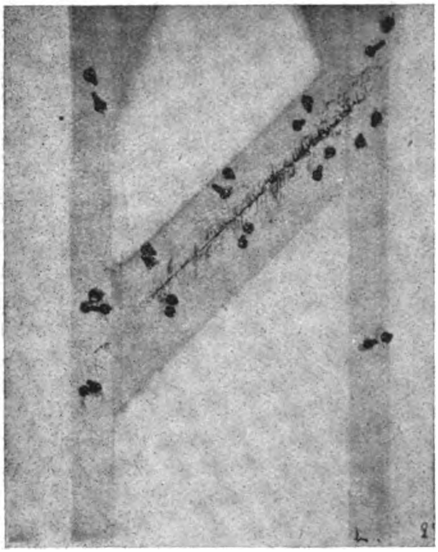


FIG. 20.—Hollow "box" Spar showing concealed and forbidden joint in plywood side.

screen examination being possible in most cases. The method is also useful for watching the behaviour of the various hidden members and joints of a composite wooden structure, while it is being subjected to test.

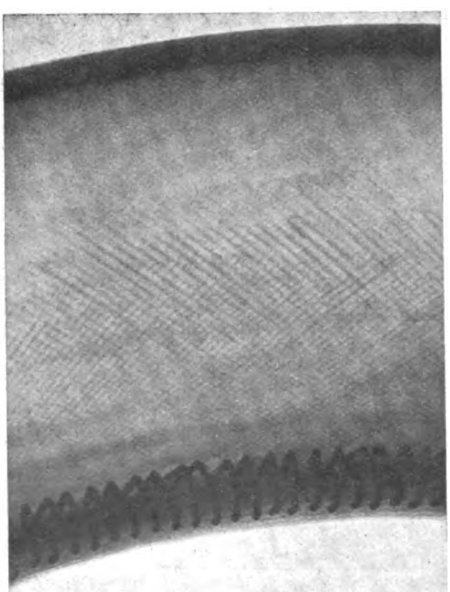


FIG. 21.—Aeroplane Tyre, showing corded structure.

X-rays are also being turned to account by the tyre manufacturer in his efforts to improve the union between the rubber and the Egyptian cotton fabric or cord. (Fig. 21). In the manufacture of golf balls, fine rubber tape is wound on a round core either of soft rubber or liquid. If care is not taken the core is distorted, becoming either roughly ellipsoidal or even dumb-bell shaped. The resulting ball is defective from the point of view of accurate flight, but such balls can be readily sorted out by

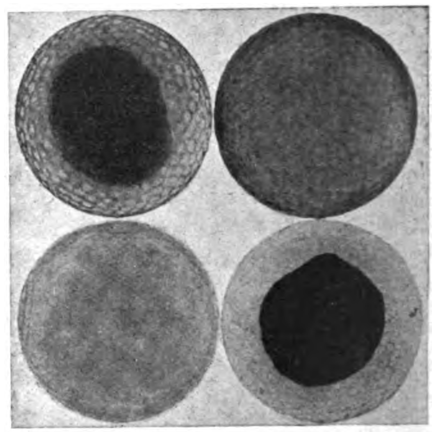


FIG. 22.—Golf Balls, showing denser and unsymmetrical cores: also "floaters"

the help of the X-rays. (Fig. 22.) The method is now in extensive use, no other being readily available. The Post Office has long used the rays for testing the amount of mineral matter in guttapercha.

The help of the X-rays has also been effectively sought by the manufacturer of carbon and graphite brushes and electrodes, to reveal mineral matter and internal cracks and flaws. The makers of electrical insulators—ebonite, built-up mica, fibre, paper, etc.—find the method invaluable for detecting the presence of metallic particles, often from the steel rollers used in the preparation of the material.

The manufacture of optical glass became a key industry during the War, as hitherto we had relied wholly on Germany for our supplies. One of the greatest troubles which was encountered was the destructive action of the molten glass on the fire clay pot, in which the components were fused. It was found that the effect was caused by the presence of iron and other impurities in the clay. Recourse was had to the X-rays,

and it was found that on examining the pots before they were fired, those containing prejudicial foreign matter could readily be sorted out. In this way much expense can be saved. The "melt" of optical glass can also be examined for inclusions before working.

X-ray photographs are useful for displaying the arrangement of concealed wiring, for example, when embedded in the interior of insulating panels or in radio apparatus. In much the same way, during the War, the X-rays were useful in scrutinising the wiring within the leather of aeroplane pilots' electrically heated clothing.

A similar field of work which the X-rays have found, is the examination of the interior of moulded articles, for example, the distributors of magnetos. During construction the insulation is moulded round the metal work, and subsequently machined. If, during the machining, blow holes are met with, the entire distributor has to be rejected.

Among the miscellaneous uses of the X-rays we can only make mention of the examination of oysters for pearls, the differentiation of lead-glass jewels from the more transparent genuine gems ; the scrutiny of artificial teeth ; the detection of contraband by the customs officials ; the sorting of fresh from stale eggs ; the detection of heavy elements in minerals, and the detection of weevils in grain, of mineral adulterants in certain powdered drugs (*e.g.*, asafoetida), and of moths in tobacco for cigars.

In quite a different direction, an enterprising American shoe store has installed a screen outfit, so that the potential customer can see his "footigraph" and satisfy himself visually whether or not the shoe he is trying on is a good fit.

The application of the cinematograph principle to X-ray photography offers wide possibilities.

We can only refer to the more academic applications of the X-rays by the conchologist to examine the interior of shells and fossils, without in any way spoiling a rare specimen. These have valuable educational possibilities and, incidentally, are often of rare beauty.

The use of the X-rays for revealing the interior of plant life is comparatively recent. Considerable differences exist in the mineral content and density, and hence the transparency of the different parts of a plant—root, stem, leaf, flower, fruit, seed, etc.—and thus it happens that even the most delicate structures of plants can be laid bare without tearing the plant to pieces in order to study it. (Fig. 23.)

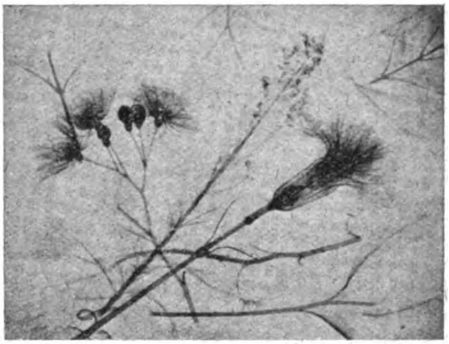


FIG. 23.—Radiograph of Carnations, Leaves, etc., showing delicate structure (Knox).

Microscopic detail is, of course, not revealed. Long-waved X-rays are required for such work.

X-RAYS AND OLD MASTERS.

The first artistic oil painting of which there is any record was executed in the year 1399, by Hubert Van Eyck, a Dutchman. From then up to the early Italian and Flemish schools, painters had possibly only eight or nine pigments, mostly mineral in origin. To-day there are over 200 in use, many of them vegetable or coal-tar in origin.

As is well-known, the imitating of valuable pictures has always enjoyed a great vogue, and there are thousands of spurious paintings in existence—copies of both late and modern masters—which have been passed as genuine and sold for outstanding amounts. For example, so far as is known, Rembrandt painted some 700 pictures, yet Maximilian Toch estimates there are fully 4,000 to 5,000 in existence, all of which are regarded as genuine and have commanded great prices. Again, it would have been absolutely impossible for any human being to have painted all the Rubens that there are in existence. The remark is probably true of every great painter.

There are various scientific methods of determining the originality and age of paintings. Photomicrography is of great help ; for example, in the case of a panel of a picture 300 years old, the protoplasm in the cells of the wood has entirely dried out, a feature unlike that of a modern panel.

Chemical analysis of tiny detached fragments often throws light on the subject; for instance, zinc white (zinc oxide) was not known 300 years ago, and the Flemish painters used flake white (white lead). Again, bitumen, at first transparent, gradually becomes opaque and insoluble with the passage of time.

But not only pictures, but all works of art, are imitated in the same way. Furniture, pottery, bronzes, old weapons and brass work are so completely simulated that experts are frequently baffled. Sheraton furniture is a familiar example. We know that Sheraton had a little shop, and did most of his work himself, with only occasional help from a few expert artisans. The amount of Sheraton furniture in existence would, however, indicate that Sheraton had a factory of several acres employing a thousand men who were life-long supporters of mass production.

It would appear that the X-rays may usefully be called in, in certain cases, as a supplementary method of scrutiny for the expert. A start has been made with pictures, as we shall now proceed to show.

In any picture we have to consider three media: (1), the surface which is painted on—usually canvas or wood, though paper, porcelain or other materials may be used; (2), the priming or sizing—now-a-days almost always white lead, though formerly carbonate of lime and glue were employed; (3), the actual pigments.

Both wood and canvas are very transparent to the X-rays, though different kinds of canvas vary a good deal. The white lead primer is much more opaque than carbonate of lime, and the former, moreover, penetrates much farther into the interstices of the canvas. This in itself is sufficient to show a marked difference under the X-rays between modern and older pictures.

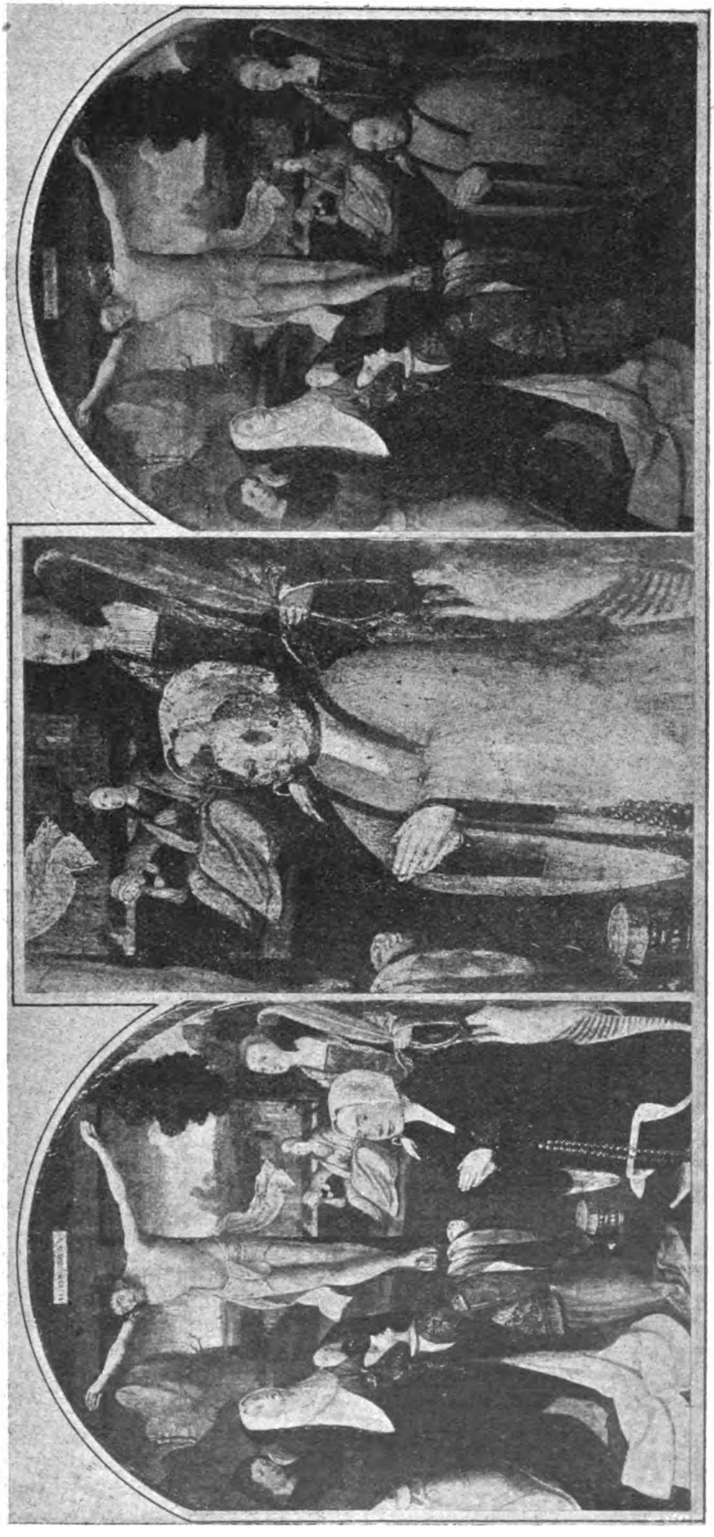
As to pigments, they vary greatly in X-ray opacity, from the opaque salts of lead, zinc and mercury to the transparent aniline derivatives and bitumen. Both modern and ancient whites are usually opaque, most of the blacks (new or old) are transparent, and modern reds are more transparent than the old reds. But, as already emarked, most of the earliest pigments are mineral in origin and opaque.

In a modern picture the sizing is very commonly more opaque than the pigments and X-ray examination is, for that reason, usually inconclusive. But, fortunately, in the pictures of the old masters, the reverse conditions hold, and thus it is that with a little experience the X-rays can be employed most usefully as a means of identifying a modern fake, or detecting alterations to an old picture. It is a practical certainty that, however skilfully the process has been carried out, the several materials used—whether canvas, priming or pigment—will differ from those in the original painting and will, in consequence, be differentiated in the radiograph.

Notable work on this subject has been carried out by Dr. Heilbron, of Amsterdam, and, more recently, by Dr. Chéron, of Paris. Among the 16th century paintings examined by the former, was the "Crucifixion," by Cornelis Engelbrechtsen, containing in the right foreground the portrait of a woman which it was suspected was that of a former "donatrice," who (after a fashion not unknown in those days) had thus sought to perpetuate her association with the picture. A radiograph of the painting showed many "restorations," especially on the right half, and beneath the portrait of the donatrice was revealed the picture of a monk in surplice and stole, the head being smaller than that of the over-painted lady. The evidence was so clear that the picture was sent to be restored at the Rijks Museum in Amsterdam, the result being to bring to light once more the monk who had been hidden for 400 years. (Fig. 24.)

Among the other paintings examined by Heilbron was a panel of the "Madonna," by Geertgen van St. Jans (c. 1500), which had always excited comment because of the apparently stiff and unnatural position of the arms. The radiograph showed that the presence of the Child in the arms of the Madonna fully explained their attitude. St. Jans is known to have painted his children disproportionately small, and the presumption is that this defect was the cause of some former owner having the Child painted out.

Other examples of Heilbron's work include a panel by De Meester van Allmaar, where the portrait of a lady (again supposed to be the donatrice), is found to be painted over the original figures. (Fig. 25.) There is some chance that the panel will be restored to its original state. A radiograph of a panel by van Dyk, representing a waterfall, a knight with a horse, dogs, etc., shows



(a) (b) (c)

FIG. 24.—Englebrechtsen's Crucifixion (c1500). On the evidence of the X-Rays the picture formerly as in (a) was restored to (c), the "donatrice" in right foreground being replaced by the priest. (b) was taken during restoration. (*Heilbron.*)

FIG. 25.—Corner of a panel by De Meister van Allmaar, showing hidden faces, etc. (*Heilbron.*)

that the artist originally painted a much bigger waterfall, the current of water appearing to pass through the animals. We are led to infer that the painting is an original and not a copy, for only in the case of the original can we trace such alterations in the ideas of the artist.

Dr. Chéron X-rayed a Flemish panel attributed to van Ostade and showing a party of country dancers and revellers. The radiograph revealed only a farmyard scene containing peacocks, ducks and chickens. The supposed van Ostade is almost certainly modern, since practically all its colours are transparent to the rays. The farmyard picture is apparently old, since the sizing is not opaque. (Fig. 26.)

The X-rays may find another field in the examination of palimpsests and ancient manuscripts which, hitherto regarded as carrying only their face value, may bear, under the trivial inscriptions of mediæval times, older matter of priceless worth. Again, it is well-known that before mill-board came into general use for book covers (about the middle of the 16th century), binders were accustomed to make them up from such loose pages as came to hand. Many discoveries of rare and valuable MSS. have been made when the bindings of old volumes have happened to fall to pieces. The X-rays may have a useful field here. It may even be that the Shakespeare folios—every vestige of which has apparently vanished—will some day be discovered in this way.

As regards antique furniture and the like, it is not improbable that examination of constructional or other detail, which cannot otherwise be viewed except by destroying the article, would suffice to reveal in a fake, craftmanship out of tune with the reputed period.

FUTURE DEVELOPMENTS OF INDUSTRIAL RADIOLOGY.

Our ideal should be to make the taking of an X-ray photograph as easy as that of light. The present limitations of radio-metallography are largely those prescribed by equipment and technique. Considerable improvements will have to come if the subject is to extend its scope and become an attractive commercial proposition in heavy engineering. If great thicknesses are to be tackled, means will have to be found so that exposures are not intolerably long. There appear to be two means to this end: (*a*) by using much heavier X-ray outputs, at much higher voltages, or (*b*) by using much more sensitive screens, plates or other detectors.

We have already considered the probable developments of the high-potential generator and, as we should anticipate, all experience agrees in demanding higher and higher

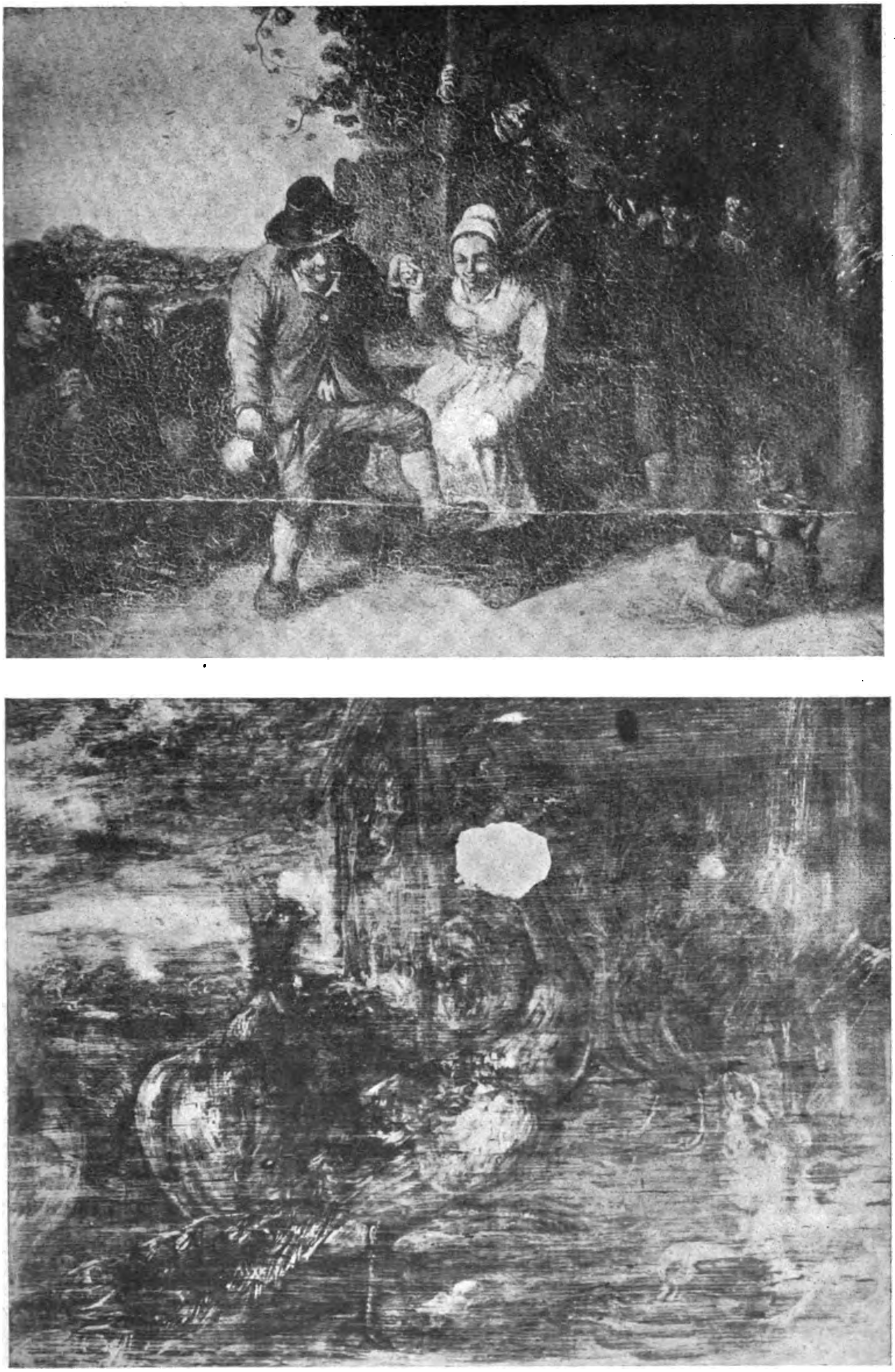


FIG. 26.—Supposed van Ostade and its radiograph. (*Chéron*).

voltages for work with metals. The ordinary Coolidge tube will, however, take no more than 180,000 volts, preferably less. This can be increased to 300,000 by lengthening the arms of the tube and completely immersing it in oil. If there is a demand for it, the electrical engineer will doubtless overcome the difficulties in the way of supplying half a million or more volts. Such transformers have already been made for other purposes, but their bulk, weight and cost are formidable. For example, a single phase transformer giving a peak voltage of one million occupies a floor space of 13 ft. x 8 ft., is 15 ft. high, has terminals 28 ft. high, weighs 20 tons and costs about £10,000. With such voltages both transformer and tube will doubtless be contained in a common oil tank, thus reducing the danger and the considerable losses by brush discharge.

Heavier discharges will demand more elaborate cooling arrangements, and probably glass tubes will not stand up to the work. We may have to turn to metal tubes radically different in design, capable of absorbing 50 H.P. or more. Furthermore, we shall have to improve the deplorable efficiency of the whole outfit.

It may be mentioned that some of the γ-rays of radium are far more penetrating than the hardest X-rays we can produce at present (being equivalent to X-rays excited by about two million volts), but, unfortunately, the intensity is so weak (not more than a few per cent. of that from a good bulb) that exposures are intolerably protracted.

As regards fluorescent screens and photographic plates, great improvements are called for. No screen at present available is sensitive enough for thicknesses exceeding ½ inch steel and only then with difficulty. Photography must be resorted to in such cases, and the time taken over the process may then become prohibitive, at any rate for routine "mass inspection."

A photographic plate only registers about 1% of the X-rays passing through it. Progress has mainly consisted in thickening the emulsion or richly loading it either with more silver or with heavier metals. Exposures may be shortened either by backing up the emulsion with a sheet of a heavy metal, such as lead, or more appreciably by the use of an intensifying screen, containing a fluorescing salt, such as calcium tungstate. All X-ray plates are much more sensitive to visible rays than to X-rays but such screens, which are more efficacious with "hard" rays than "soft," are apt to impair the detail in certain classes of work, owing to "grain." It is important to have the closest contact between the screen and the emulsion. This is secured in the new "Impex" plate in which the fluorescing salt is contained in a superimposed gelatine film which is dissolved off before the plate is developed. Such plates reduce the exposure 20 to 30 times with hard rays, but the figure is much lower for long-waved rays.

Another real advance in X-ray photography has proved to be the duplitized film, *i.e.*, a film coated with emulsion on both sides of the celluloid. A "pile" of several of these sandwiched with thin fluorescent screens, gives a very sensitive detector.

The ionisation method of detecting the X-rays offers great promise, for it can be made more sensitive than any photographic method at present available. An explorer built on these lines and of convenient design would have corresponding advantages.

To conclude, the subject of industrial radiology is young and, although progress has been rapid, we must in all fairness be careful not to claim too much for it. From such experience as we have had it does appear, however, that the method is settling down to be a valuable laboratory tool, supplementing those which are already available for testing materials. Incidentally, the existence of the method is not without its moral effect on the personnel, as regards standard of workmanship.

OBITUARY.

JOHN WILSON.—The Society has lost a Fellow of very long standing by the death of Mr. John Wilson, which took place recently at his residence in Leek, Staffordshire, at the age of 74. Mr Wilson was elected a life Member of the Society in 1868. He was formerly in business in Bond Street, but he retired and went to live in Leek about twenty years ago. He was a man of very wide and various interests. He had travelled much in earlier life; he was a lover of music (being himself a fine organist) and art, a skilful etcher, and a keen collector of etchings and Japanese works of art. He was also much interested in meteorology and kept temperature and rainfall records for 17 years. Among his other pursuits were gardening and and the making of rugs, some of which were

admirable specimens of work. Of late years his chief hobby was Esperanto, and he devoted a great deal of time to transcribing Esperanto into Braille for the benefit of blind readers.

NOTES ON BOOKS.

ARTISTIC LEATHER WORK: A HANDBOOK ON THE ART OF DECORATING LEATHER. By G. Ellin Carter. Second edition. London: E. & F. N. Spon, Ltd. 3*s*. 6*d*. net.

This book has been written to supply a want much felt by most beginning to study leatherwork, that is, a simple and reliable guide to artistic leather decoration. Such a thing did not appear to exist before the publication of this volume. The author gives practical directions, illustrated by figures, which will be easily understood by young students. The principal tools employed are described and instructions are given as to the manner in which they should be used. Various kinds of leather are also discussed, together with the best materials for staining and colouring, and the different methods of decoration, incised, embossed, modelled, carved, hammered, and mosaic, are dealt with. Altogether this is an exceedingly compact and useful handbook, which may be cordially recommended to students of leatherwork.

(1) TRANSPORT AND THE EXPORT TRADE (2*s*. 8*d*. net); (2) THE IMPORT TRADE (2*s*. net); (3) THE USE OF GRAPHS IN COMMERCE AND INDUSTRY (2*s*. net). By A. Risdon Palmer, B.Sc., B.A. London: G. Bell and Sons, Ltd.

The Commercial Degrees Committee of the University of London recommended, among other things, that the range of manuals available for students should be modernized. Messrs. G. Bell and Sons, Ltd., have taken note of this, and have begun to publish a series of "Handbooks of Commerce and Finance," of which the volumes named above form the first three. The author's aim has been to make his material real and actual, and to this end he has taken his examples from practical commercial problems and has reproduced in facsimile specimens of commercial documents, such as bills of lading, insurance policies, customs specifications, consular invoices, etc. These plates should be very useful in rendering students familiar with the appearance and contents of such documents. A great many examples are given, and most of these are types of problems which might have to be dealt with in any merchant's office. One is, however, a little surprised to find among these a few questions in the simplest of simple equations which would be more in place in an elementary text book on algebra than in a handbook on commerce.

CHINESE RAILWAYS.

Its vast area and enormous population, coupled with the immense value of its resources, will, in the near future, compel a considerable development of the railway facilities of China.

So far, South China has shown itself to be less progressive than the territory north of the Yangtze, but this apparent backwardness is due in part to the excellence of the inland waterway communications. On the whole, however, the Chinese have not been slow to recognise the economic advantages of good railway systems, and the probabilities are that within the next twenty-five years some 50,000, or even 100,000, miles of new track will be built, linking up the principal ports. Practically all the railways in North China are commercially successful, and the traffic on all lines is steadily increasing.

Amongst the projected developments is a line 600 miles long, connecting the hinterland of the south-west with the Yangtze and with Szechuan, a spur affording connection with the railways of French Indo-China. The opening up of Hunan and Kwangshi will be facilitated by the proposed Chuchow-Chinchow railway; whilst in connection with railway schemes in the Canton district, there is a project for constructing a deep-water port ten miles below that city.

Not the least amongst the troubles of the maintenance engineer is the white ant problem. In the south especially, owing to the ravages of this insect, wooden sleepers have only a short life. The difficulties occasioned are accentuated by the fact that there is very little available home-grown timber, most of the wood required for sleepers being imported from the north island of Japan. Accordingly, experiments have been made with steel sleepers, and a type evolved for the Shantung Railway has given efficient service.

More freight-cars and locomotives are badly needed on the Chinese Government Railways. On the Pekin-Mukden line traffic has increased 50 per cent. during the last five years; but against this there has only been a 22 per cent. increase in the freight-car stock and a 21 per cent. increase in locomotive-power. At the present time, the Chinese railways possess a more varied assortment of equipment than any other equal mileage in the world. The greater proportion of the rolling-stock is of very small carrying capacity, though the nature of the traffic seems to call for high-capacity freight cars and correspondingly heavy motive-power. Air brake equipment is general on the passenger cars only.

On the lines built by Chinese engineers with Chinese capital there is a considerable quantity of American rolling-stock and material in use. Of the 66 locomotives owned by the Pekin-Suiyuan line, 60 are American built.

Methods of operation on the Chinese lines

require more man-power than is the case in other countries. Labour is cheap, and the labourers themselves are highly industrious, for which reasons very few labour-saving devices are employed. The individual lines reflect, to a large degree, the characteristics of the nation which loaned the capital required for their construction. In the case of the French, Belgian and German built lines, there is a serious and increasing handicap in the bridges erected along these lines. These bridges are only suitable for light loads, and, furthermore, the floor system adopted is disadvantageous, there being risk of entire failure in the event of a derailment taking place. Before heavier motive-power and rolling-stock can be introduced—and such are necessary—many bridges will have to be replaced.

LIME INDUSTRY IN FINLAND

The lime-burning industry is an old one in Finland. The Pargas lime deposits are the largest and richest in the country. The largest deposit at Pargas is 1½ kilometers (kilometer= 0.621 mile) long and 400 metres (metre=3.28 feet) wide. Borings have been made in this to a depth of 30 metres, but it has been ascertained that it is at least 60 metres deep, and the quality of the stone appears to improve with the depth.

According to a report by the U.S. Consul at Helsingfors, the lime was at first produced in earth kilns, but in 1877 the cylinder oven was invented, and nine were subsequently installed at Pargas. The Pargas Kalkbergs Aktiebolag was organised in 1898. It built a rotary oven in 1905, which increased its production ten times. A similar oven was built in 1912. The total production of the Pargas Co., which, in addition to its plant at Pargas, has rented a lime deposit from the town of Willmanstrand and also has a plant in Helsingfors, is from 1,200,000 to 1,500,000 hectolitres (hectolitre= 2.837 bushels) per annum.

The lime deposits in Lojo were first worked in 1897 and a modern oven was built there in 1907. The Lojo Kalkverk Aktiebolag was organised in 1914, and the company owns about 2,000 acres of land. Its annual production of limestone powder and of slaked and unslaked lime is about 250,000 hectolitres.

The lime industry in Finland, like the cement industry, is considerably handicapped at the present time by having to use wood in place of coal, which necessitates the employing of many more labourers than would otherwise be needed.

GENERAL NOTES.

Population of France.—The partial results of the last Census in France have just appeared in the *Journal Officiel*. From this it seems that the total population in that country is 36,084,206 inhabitants, as compared with 38,468,813 in 1911, showing a decrease of 2,384,607. These figures do not, however, include the soldiers and sailors who were absent from France on the 6th March, the troops on the Rhine, in the East, in Upper Silesia or in Morocco.

Petroleum.—A new volume, dealing with petroleum, in the Series of Monographs on the Mineral Resources of the Empire, issued under the direction of the Mineral Resources Committee of the Imperial Institute, has just been published by Mr. John Murray (Price 5s.). This monograph has been prepared jointly with H.M. Petroleum Department with the assistance of Mr. H. B. Cronshaw, B.A., Ph.D., A.R.S.M. The world's output of petroleum during the last fifteen years has increased from 35 million tons to upwards of 90 million tons. The first chapter describes the characteristics of petroleum, the geological distribution of oil in the chief oil fields, the causes which have affected the transference or migration of oil, drilling for oil and the methods of refining it, and the uses of petroleum products. In the second chapter the deposits of the British Empire are described, especially those of India, Egypt, Ontario and Trinidad. The third and last chapter deals with the petroleum of foreign countries, more particularly Poland, Roumania, Russia (Ural-Caspian region), Georgia (the Caucasus), Dutch East Indies, Japan, Persia, Mexico, the United States, Argentina (Comodora Rivadavia) and Peru. Statistical tables give imports, exports and production, and the chapter concludes with a map showing the principal petroleum deposits of the world, and a list of the chief publications on petroleum.

Chinese Prejudices Regarding Colour.—The fact that the Chinese give evidence of decided ideas of their own as to the use of colours in materials, wrappings, and poster advertising, was recently commented upon by the United States Bureau of Foreign and Domestic Commerce. Such prejudices have been known to cause a Chinese customer to change his patronage merely because of the colouring of packing paper used. Though no definite rule can be applied to all commercial uses of colour, it can be said generally that gold, yellow, red, bright brown, purple, and certain shades of pink are good colours. Gold is a dignified colour, red the colour of good fortune. Imperial yellow is good for rugs, carpets, and curtains. White and blue are mourning, and should be avoided as well as green, which is associated with misfortune. The designing of posters and advertising matter should always be handled by agencies in China who are familiar with the tastes and prejudices of the communities involved.

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FRIDAY, OCTOBER 14, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

COUNCIL.

On Monday, October 10th, the Council elected the Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S., a member of the Council and Vice-President of the Society in place of Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., whose engagements during the winter will prevent his attending meetings of the Council.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RECENT APPLICATIONS OF THE SPECTROSCOPE AND THE SPECTROPHOTOMETER TO SCIENCE AND INDUSTRY.

By Samuel Judd Lewis, D.Sc., F.I.C., Ph.C.

Lecture I.—*Delivered April 11th*, 1921.

It is just 35 years since the late Professor Hartley stood in this place and delivered a lecture on "Photography and the Spectroscope in their applications to Chemical Analysis." (J. Soc. Arts. 1886, XXXIV, 396-418). He described the principles and construction of one of the earliest models of the quartz spectrograph, and spoke of the prism in the instrument as being specially designed by M. Cornu, the design having been communicated to him privately. To-day the Cornu prism, then described as a novelty, is well-known and finds a place in most quartz spectrographs intended for investigation of the ultra-violet spectrum.

The professor demonstrated many applications of the instrument to scientific and technological purposes, and so the present course may in some respects be regarded as a continuation of the same fascinating story.

Since those days spectroscopy has made great strides, not only in experimental procedure and in the light it throws on the composition and properties of materials, but even more in physical theories and in elucidating the ultimate structure of matter. So wide have its applications become that rarely does any single number of certain chemical and physical journals appear without more or less extensive reference to this branch of science, while to-day none of the natural sciences is independent of its influence. It is the spectroscope which reveals to us the elements composing the sun and stars; and it is the same which affords the means of studying their history and certain of their movements. Again it is by the same means that we can ascertain the nature of the mineral matter in a microscopic particle of some material or discover the trace of boron present in a few drops of natural water.

Of so vast a subject it is impossible to explore any large field in the course of three or four hours. One is tempted to examine the wonderful work which the mathematician, the physicist and the astronomer have accomplished by means of spectroscopy during the last few years, and to study their discoveries in the properties of energy, the structure of the atom and kindred subjects.

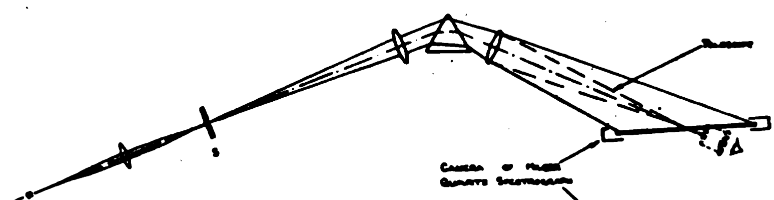
But not less fascinating are many of the recent applications of the spectroscope in the chemical laboratory, and it is these together with those of the newly invented sector spectrophotometers which will engage most of our attention during the brief hours at our disposal.

We will, therefore, proceed at once to consider some recent work on emission spectra, and in the two following lectures to

learn something of the possibilities of spectrophotometers in relation to modern absorption spectroscopy and other quantitative investigations. It will be more profitable and interesting to consider a few instances in detail rather than to indulge in generalities.

We begin then with emission spectra, those which are produced from the light emitted by the substance under investigation.

I assume that most here are familiar with the ordinary spectroscope, designed for study of the visible spectrum. The arrangement consists of the light source, which may be a flame, arc, spark or vacuum tube, a "condenser," which is merely a lens, preferably a sphero-cylindrical lens, for focussing the light on the slit, the slit which should usually be very narrow, *e.g.*, 1/20th to 1/100th mm. according to the brightness of the light and the purity of the spectrum required, a collimating lens which, being focussed on the slit, projects a parallel beam on the face of the prism, the prism by which the spectrum is produced, and a telescope wherewith to view the spectrum. The optical train is shown in our first figure, and the appearance of the spectrum is seen in either one of the



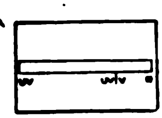


FIG. 1.—Showing the optical train in (*a*) a visual spectroscope, using a telescope; (*b*) a quartz spectrograph; the aperture in the back of the camera is filled with the visible spectrum from V (violet) to R (red), and the ultra-violet spectrum UV to UV.

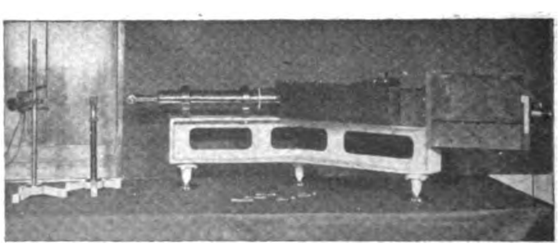


FIG. 2.—Quartz spectrograph with arc lamp and condenser.

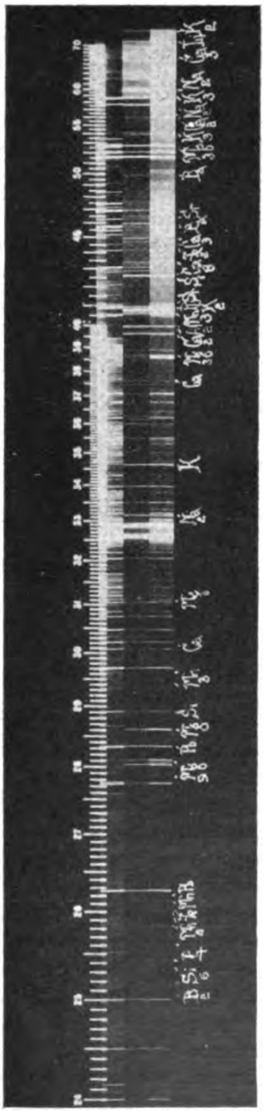
three bands in Fig. 3.

If the telescope is replaced by a photographic camera, the whole instrument is known as a spectrograph. Therefore, the spectrograph is related to the spectroscope in the same way as the ordinary camera is related to the telescope.

The quartz spectrograph described by Hartley, finds its modern representative in the one shown in Figure 2. In the later instruments all the optical parts are mounted directly on the heavy iron stand, so as to avoid alterations in adjustment due to warping of the wooden mounts formerly used. The camera itself is so far made of wood, but trials are now in progress to replace even this by metal, so that the new ideal is the all-metal quartz spectrograph. Its optical train is very simple, and is similar to that for the visible, except that all the parts are made of quartz instead of glass, and that, owing to certain peculiarities in the properties of quartz, the prism is of the Cornu type, and, for the purpose of focussing, the plate is slightly curved and set at an angle of 27° with the optical axis of the instrument as shown in Fig. 1. The instrument is in permanent adjustment.

A wave-length scale, composed of a plate of silver pierced stencil fashion with the graduations and numbers, can be thrown up against the plate, and a photograph produced by switching on a very small electric light for a second or two. The scale will appear in most of the photographs

to be shown. The great advantage of instruments of this type is that they embrace the whole of the visible region, and also the ultra-violet as far as 2100. The full significance of this is realised only in practice. Suffice it to say, that whereas with the well-known arrangement of a visual spectroscope and flame lamps, the range of elements is limited to the alkali metals, the alkaline earths, indium and thallium, the quartz spectrograph with an arc lamp permits under equally convenient conditions, the discovery and identification of traces of all the metals as well as of the four non-metals, boron, silicon, phosphorus and arsenic.



(The region to the left of "40," i.e., 4000 wave-length, is ultra-violet, that to the right is the visible region.)

Fig. 3.—Comparison spectra: (*a*) top band, copper only; (*b*) middle band, copper and the ash of the root of Baptisia tinctaria; (*c*) copper and the ash of a tincture made from the same root.

The technique of the experiment is very simple. The slit of the spectrograph is usually fitted with a "wedge" having three apertures, wherewith one may expose either the upper, middle or lower third of the height of the slit. The apertures are so related that the resulting photographed spectra are in juxtaposition, as in Fig. 3.

The lower aperture is first brought in front of the slit. A very simple "scissors" arc lamp works well when fitted with two vertical copper wires (¼in.), one above the other, to serve as electrodes. An arc is struck, and the spectrum of pure copper is photographed.

The middle aperture is then brought in front of the slit, and on the top surface of the lower electrode a little, a few milligrams, of the substance to be examined is placed, and the arc struck again. A second spectrum photograph is taken; this will consist of the spectrum of copper from the electrodes combined with the spectrum of the substance.

After development, the two photographed spectra are found in juxtaposition on the plate as in the top and middle bands in Fig. 3. The lines characteristic of copper run through both bands. The lines due to the elements in the substance under investigation occur in the middle band only. (Owing to optical inversion, the upper aperture corresponds with the lower photograph).

It is now necessary to identify the several new lines either by comparison or by wave-length measurements, and so ascertain the elements which they signify.

If a spark be used in place of the arc, the general procedure is the same, but the substance can rarely be exhibited in such simple fashion; it may, however, be employed in the form of solution, which is not easily possible with the arc.

Some examples of work done in this way may now be given.

First of all, spectroscopy holds the premier position as a means of detecting and identifying minute quantities of the elements. A mere trace, perhaps half a milligram, of a soot-like stain on the lead of an electric lamp was carefully removed, transferred to the electrode of a small arc lamp, such as that already described, and by the spectrum of its incandescent vapours, identified as a mixture of tungsten and iron. Not only was the presence of these elements demon-

strated, but simultaneously the absence of most other elements in a proportion greater than one per cent. was signified. This last advantage of the spectrographic method, the demonstration of the absence of other elements, is often of more value than the evidence of traces of impurities.

A single drop of London tap water on drying down on an electrode and arcing reveals the presence of the sodium, magnesium and calcium it contains, although the total solids do not exceed the fiftieth part of a milligram or the three-thousandth part of a grain.

In the ordinary course of laboratory work, the photograph registers the ten-thousandth part of one per cent. of lead when present in a complex mixture, even if only a few milligrams of the material are available. Thus the one-hundred-thousandth part of a milligram or the one-six-millionth part of a grain is sufficient, not only for the detection, but also for the identification of the metal, while a fair estimate of the proportion present may also be made.

But the spectrograph is not merely a useful toy for discovering traces. It has much more important functions to perform.

It will be recalled that one of the earlier applications of spectroscopy by Bunsen, Kirschoff and others was to the investigation of various natural waters, and that in the course of this inquiry rubidium, caesium and other elements were discovered. The waters of several Continental spas were exhaustively analysed in this way, but not much appears to have been done in this country. However, recently some effort has been made over here, as exemplified by the following analysis in 1918 of the Rushy Valley Spring at Malvern. The older published figures resulting from chemical analysis and relating to the neighbouring St. Ann's Well, are tabulated along with the former for the sake of comparison.

ANALYSIS OF MALVERN WATERS.

	Spectrographic and Chemical. Rushy Valley Spring.	Chemical only. St. Ann's Well.
	gr. per gal.	
Calcium Carbonate (as $CaCO_3$)	0.42	0.4310
Magnesium Carbonate (as $MgCO_3$)	0.40	0.4111
Sodium Carbonate (as Na_2CO_3)	0.29	0.2844
Iron Carbonate (as Fe_23CO_3)	0.02	0.0331
Calcium Sulphate (as $CaSO_4$)	1.14	1.1521
Barium Sulphate (as $BaSO_4$)	0.035	—
Magnesium Sulphate (as $MgSO_4$)	0.20	—
Sodium Sulphate (as Na_2SO_4)	0.44	0.4382
Potassium Sulphate (as K_2SO_4)	(included with the Sodium Sulphate)	—
Magnesium Chloride (as $MgCl_2$)	0.08	0.1448
Sodium Chloride (as NaCl)	0.88	0.8763
Potassium Iodide (as KI)	—	traces
Silicic Acid (as SiO_2) ..	0.59	0.2057
Lithium Carbonate (as Li_2CO_3)	0.01	—
Strontium Carbonate (as $SrCO_3$)	0.004	—
Zinc Carbonate (as $ZnCO_3$)	0.01	—
Lead Carbonate (as $PbCO_3$)	0.0003	—
Chromium Sulphate (as Cr_23SO_4)	0.004	—
Aluminium Sulphate (as Al_23SO_4)	0.003	—
Boric Acid (as B_2O_3) ..	0.003	—
Silver	trace (?)	—
Water, CO_2, etc.	.32	
Total Solids	4.85	3.9772

It will be seen that the larger figures of the two waters are nearly identical, except that the silica in the one is much greater than in the other. But the spectroscope has revealed the presence of small quantities of no fewer than nine extra elements, namely, lithium, strontium, barium, lead, zinc, chromium, aluminium, boron and possibly silver, which find no place in the older, purely chemical analysis. In these days, when the influence of minute quantities is so widely recognised, the role played by the long-continued regular assimilation of the less familiar elements by the human system cannot be regarded as insignificant.

In the course of a spectrographic examination of the ashes of several drugs and of the ashes of the tinctures prepared from them (Yr. Bk. of Pharmacy, 1914, 361-370).

it was discovered that boron was present in all. This inspired doubt, at first, lest boron was creeping in from some laboratory source. However, on extending the inquiry it was found that boron is present in minute proportion in the majority of vegetable and animal substances. As the same means have revealed the occurrence of boron in the majority, although not all, natural waters, it is probable that the wide distribution of boron originates in the water supplies. That is among the more recent discoveries made by means of the spectrograph. (J.S.C.I., 1916, 661.)

Another fruit of the same spectrographic research was knowledge derived respecting the movements of the inorganic elements of a drug in the course of a pharmaceutical process. In Fig. 3 there are three spectra in juxtaposition. The first is that of the copper electrodes of the arc lamp used. The second is the combined spectra of the electrodes and of the ash of the root of Baptisia tinctoria. The new lines express the composition of the ash. The third is the combined spectra of the electrodes and of the ash of an alcoholic tincture of the same sample of drug. Here, similarly, the new lines reveal the elements present in the ash of the tincture. By comparing the new lines in the second and third spectra and marking their differences, we see how and to what extent the relationship of one inorganic element to another has been affected during the process of tincture making. For observe that the relative intensities of the lines indicate that although the process of tincture making has made little difference to the proportions of the alkali metals, the proportions of the others have been more or less greatly affected. The alkaline earths have decreased, indeed, the strontium and barium have disappeared; and the same applies to iron, aluminium, silicon and boron.

Comparative work of this kind may be applied to many physiological investigations, whether animal or vegetable. The migration of inorganic elements from one part of an organism to another may be watched with very interesting and significant results.

Such *comparison spectra* assist in opening up many wide fields under exploration. By their means one may learn how two materials differ in composition without the necessity of making any direct analysis at all. This has proved so in the glass industry. Indeed, this "Key industry" has been greatly assisted in its recent development by reference to the spectrograph.

For instance, two glasses "A" and "B" were examined in this way, the three spectra showing (*a*) copper only in the top band, (*b*) copper and glass "A" in the middle band, and (*c*) copper and glass "B" in the bottom band, as in Fig. 3. From this, by the significant lines present, and their relative intensities, it was learnt that glass "B" contained a notable quantity of zinc, which was not the case with glass "A", and since traces of lead and arsenic were also present in "B" but not in "A", it may be assumed that they were introduced as impurities accompanying the zinc. The relative intensities of the lines indicate that "A" contains more calcium and silicon, but less magnesium and boron than "B" does.

Spectroscopy is not entirely without pitfalls. While the spectrograph never tells a lie, the observer does not always read the truth; but with a little experience and with the exercise of that faculty usually known as "common sense," the results are, as a rule, quite unimpeachable.

An instance may be cited by way of illustration.

An ore was examined with a view to ascertaining the presence of rubidium and caesium. The direct spectrum of the whole ore revealed the presence of rubidium. Caesium was indicated by a single faint line, and that line was its most persistent line. If the wave-length of this had been determined with very great care, it would have been conclusive evidence. However, such precision is not always convenient, and it happens that the most persistent line of barium has nearly the same wave-length as has that of caesium (Ba 4554.2, Cs. 4555.4), and so it was desirable to obtain some decisive distinction. This was done by chemical separation into the alkali and alkaline earth groups, using a trace of sulphate, and subsequent spectrography. The spectrum of the alkaline earth group revealed not only the most persistent line for barium, but also that at 4934.2, while the spectrum of the alkali group showed that caesium was absent; only a ghost of a line indicative of barium being seen, which was indeed evidence of the slight solubility of barium sulphate.

We have now demonstrated the value of the spectrograph as an aid to qualitative chemical analysis. It remains to show to what degree the method can be made quantitative. That the work can be made quantitative was amply proved in the lecture by Professor Hartley 35 years ago. He analysed a sample of limestone by the spectrograph and found it contained 3.5 per cent. of magnesium carbonate and 92.5 per cent. of calcium carbonate, total 96.0 per cent. He then analysed it by the usual chemical methods and found as a mean 4.45 per cent. of magnesium carbonate and 91.78 per cent. of calcium carbonate, total 96.23 per cent. The results agree so closely that there can be no question as to the possibility of fairly accurate work. The only criticism to be levied is the large amount of time and care devoted to it, as revealed by his description. Such lengthy procedure places the method outside the bounds of ordinary economic laboratory practice.

Hartley's method has been developed by the late Dr. Pollock and Dr. Leonard of Dublin, and they have published several papers on "Quantitative Spectra" in the Scientific Proceedings of the Royal Dublin Society. These workers applied a fairly powerful spark to a series of solutions of the chlorides of the metals contained in the material, and found the concentration at which the most persistent lines of the element in question ceased to appear. By comparison with standard solutions similarly treated, the quantitative determination s made. Details of the modus operandi are described in the paper referred to.

The tendency in technological circles, however, is to use the arc. It is quicker and more convenient for practical work and a fair degree of accuracy is attainable, sufficient for many industrial and scientific purposes.

For example, an inquiry as to the possibility of applying the arc method to he determination of minute quantities of nickel in fats led to the following results. (See J. Soc. Chem. Ind., 1916, 663.)

Two series of trial experiments were made with minute quantities of nickel salt mixed into 20 gms. of soda crystals. The quantities introduced and found are displayed in the following table.

Introduced	Found	
	A	B
0.1 mgrm. Ni	——	0.1 mgrm. Ni
0.05 „	0.04 mgrm. Ni	0.045 „
0.025 „	0.03 „	0.025 „
0.01 „	0.01 „	——

Two series of determinations were then made on samples of soda residues obtained on igniting soap. The results are compared in the following table with those obtained in the usual way by chemical methods in a large soap works.

	Spectrographic	Spectro-graphic	Chemical
	% Ni	% Ni	% Ni
A.	0.00004	0.00004	0.00001
B.	0.00002	0.000035	0.00002
C.	Absent or very little	0.00001	0.00006
D.	0.000005	0.000005	0.00005
E.	0.00004	0.00005	0.00005

The figures in the first two columns show that the values obtained spectrographically agree well among themselves; while in the third column it is seen that they are of the same order as the chemical figures, although not always of quite the same magnitude.

All these results were obtained by ordinarily careful experiment in the course of the usual laboratory practice.

Another example emanates from the United States. The details of the procedure appear in the Transactions of the American Electrochemical Society (1917, 32, 335) under the authorship of Hill and Luckey. Their method is interesting in that the observations were made visually through an eye-piece directed towards a concave grating ruled with 15,000 lines to the inch.

Another point of interest is that whereas it is usual in quantitative spectroscopic processes to make the assay by comparing the intensity of the lines in question with a standard, or, as in Hartley's and Pollock's process, by ascertaining the concentration at which the significant lines cease to persist;

the authors record the time in seconds required for the disappearance of the line in question, or for its reduction to a standard dimness, under constant conditions of experiment

Their object was to determine the magnitude of the traces of lead found in the copper derived by a certain refining process.

Their method is to place 0.4 g. of the impure copper in a graphite cup, which forms the positive electrode for an arc, the smaller negative carbon electrode being placed just above. The electrical and other conditions of experiment are controlled to a constant. They worked with coppers containing 0.004 to 0.216 per cent. of lead and obtained results which did not usually differ by more than 5 or 6 per cent. from the truth. They say, however, that "several check readings should be taken when considerable accuracy s desired."

Another metallurgical example may be cited. The relative proportions of cadmium in a series of samples of zinc were ascertained spectrographically by comparing the intensity of the photographed lines with those in standard spectrograms. The values are set out in the first column of the following table, compared with the proportions found by the usual chemical process.

	Spectrographic.	Chemical.
A.	0.002	trace
B.	0.08	0.09 per cent.
C.	0.18	0.16 ,,
D.	0.16	0.15 ,,
E.	merest trace	trace

All this goes to show that good approximations may be made by spectrographic methods in the ordinary course of laboratory practice, and that the components of a mixture may be evaluated fairly precisely by taking a considerable amount of care.

It is, however, as unreasonable to expect that all classes of compounds can be either qualitatively or quantitatively analysed by one stereotyped spectroscopic process as it would be to expect it of one arbitrary chemical process. It remains, therefore, to elaborate a reliable system of procedure for each element under various circumstances, by which it may be determined spectrographically just as has been done in gravimetric chemical analysis.

An example of the utility of the spectroscope in throwing light on physical conditions is afforded by the spectrum of an acetylene flame. The spectrum is continuous. In view of *continuous* spectra being characteristic of incandescent solid bodies, it follows that the high luminosity of an acetylene flame is due to solid particles of carbon at a very high temperature. That this is the physical condition of the flame is generally accepted, for by depressing a cold body into the flame a rich deposit of carbon is obtained. But in doing this, the condition of the flame is altered, and hence the value of the test is reduced, for the freedom of the carbon might possibly be the result of the disturbance. The spectral observation is free from this uncertainty, for the flame is in no way disturbed while making the experiment.

ORGANIC CHEMISTRY.*

Many and various are the reasons which have been urged, at different periods of its history, for stimulating the study of chemistry. In recent years these have been either defensive or frankly utilitarian, in the latter feature recalling the less philosophic aspects of alchemy; moreover, it is to be feared that a substantial proportion of those who have lately hastened to prepare themselves for a chemical career have been actuated by this inducement. It is the duty, therefore, of those who speak with any degree of experience to declare that the only motive for pursuing chemistry which promises anything but profound disappointment is an affection for the subject sufficiently absorbing to displace the attraction of other pursuits. Even to the young chemist who embarks under this inspiration the prospect of success as recognised by the world is indeed slender, but, as his knowledge grows and the consequent appreciation of our ignorance widens, enthusiasm for the beauty and mystery of surrounding nature goes far in compensating for the disadvantages of his position. On the other hand, he who has been beguiled into embracing chemistry on the sole ground of believing it to be a "good thing" will either desert it expeditiously or almost surely starve and shower purple curses upon his advisers.

In one respect chemistry resembles measles—every boy and girl should have it, lest an attack in later life should prove more serious. Moreover, whilst it is not only unnecessary, but most undesirable, to present the subject as if every boy and girl were going to be a chemist, it is most important to present it in

* Extracted from the Presidential Address on "The Laboratory of the Living Organism," delivered by M. O. Forster, D.Sc., F.R.S., President of the Chemical Section of the British Association.

such a manner that every educated citizen may realise the intimate part which chemistry plays in his daily life. Not only do chemical principles underlie the operations of every industry, but every human being—indeed, every living plant and animal—is, during each moment of healthy life, a practical organic and physical chemist, conducting analytical and synthetical processes of the most complex order with imperturbable serenity. No other branch of knowledge can appeal for attention on comparable grounds; and without suggesting that we should all, individually, acquire sufficient chemical understanding fully to apprehend the changes which our bodies effect so punctually and so precisely—for this remains beyond the power of trained chemists—it may be claimed that an acquaintance with the general outlines of chemistry would add to the mental equipment of our people a source of abundant intellectual pleasure which is now unfairly denied them. We have been told that the world shall be made a fit place for heroes to live in; but is not the preliminary to this ideal an exposition to those heroes of the wonder and beauty of the world which they already occupy on the principle that if you cannot have what you like, it is elementary wisdom to like what you have? In following the customary practice of surveying matters of interest which have risen from our recent studies, therefore, it is the purpose of this address to emphasise also those æsthetic aspects of chemistry which offer ample justification for the labour which its pursuit involves.

What is breakfast to the average man? A hurried compromise between hunger and the newspaper. How does the chemist regard it? As a daily miracle which gains, rather than loses, freshness as the years proceed. For just think what happens. Before we reach the table frizzled bacon, contemplated or smelt, has actuated a wonderful chemical process in our bodies. The work of Pavlov has shown that if the dog has been accustomed to feed from a familiar bowl the sight of that bowl, even empty, liberates from the appropriate glands a saliva having the same chemical composition as that produced by snuffing the food. This mouth-watering process, an early experience of childhood, is known to the polite physiologist as a "psychic reflex," and the various forms assumed by psychic reflex, responding to the various excitations which arise in the daily life of a human being, must be regarded by the chemical philosopher as a series of demonstrations akin to those which he makes in the laboratory, but hopelessly inimitable with his present mental and material resources. For, extending this principle to the other chemical substances poured successively into the digestive tract, we have to recognise that the minute cells of which our bodies are co-ordinated assemblages possess and exercise a power of synthetic achievement contrasted with which the classical syntheses, occasionally enticing the modern organic chemist to outbursts of pride, are little more than hesitating preliminaries. Such products of the laboratory, elegant as they appear to us, represent only the fringe of this vast and absorbing subject. Carbohydrates, alkaloids, glucosides and purines, complex as they seem when viewed from the plane of their constituent elements, are but the molecular debris strewing the path of enzyme action and photochemical synthesis, whilst the enzymes produced in the cells, and applied by them in their ceaseless metamorphoses, are so far from having been synthesised by the chemist as to have not even yet been isolated in purified form, although their specific actions may be studied in the tissue-extracts containing them.

Reflect for a moment on the specific actions. The starch in our toast and porridge, the fat in our butter, the proteins in our bacon, all insoluble in water, by transformations otherwise unattainable in the laboratory are smoothly and rapidly rendered transmissible to the blood, which accepts the products of their disintegration with military precision. Even more amazing are the consequences. Remarkable as the foregoing analyses must appear, we can dimly follow their progress by comparison with those more violent disruptions of similar materials revealed to us by laboratory practice, enabling such masters of our craft as Emil Fischer to isolate the resultant individuals. Concurrently with such analyses, however, there proceed syntheses which we can scarcely visualise, much less imitate. The perpetual elaboration of fatty acids from carbohydrates, of proteins from amino-acids, of zymogens and hormones as practised by the living body are beyond the present comprehension of the biochemist; but their recognition is his delight, and the hope of ultimately realising such marvels provides the dazzling goal towards which his efforts are directed.

The Vegetable Alkaloids.

The joyous contemplation of these wonders is an inalienable reward of chemical study, but it is denied to the vast majority of our people. The movements of currency exchange, to which the attention of the public has been directed continuously for several years, are clumsy contortions compared with the chemical transformations arising from food exchange. It should not be impossible to bring the skeleton of these transformations within the mental horizon of those who take pleasure in study and reflection; and to those also the distinction between plants and animals should be at least intelligible. The wonderful power which plants exercise in building up their tissues from carbonic acid, water and nitrogen, contrasted with the powerlessness of animals to utilise these building materials until they have been already assembled by plants, is a phenomenon too fundamental and illuminating to be with-

held, as it now is, from all but the few. For by its operation the delicate green carpet, which we all delight in following through the annual process of covering the fields with golden corn, is accomplishing throughout the summer months a vast chemical synthesis of starch for our benefit. Through the tiny pores in those tender blades are circulating freely the gases of the atmosphere, and from those gases—light, intangible nothingness, as we are prone to regard them—this very tangible and important white solid compound is being elaborated. The chemist cannot do this. Plants accomplish it by their most conspicuous feature, greenness, which enables them to put solar energy into cold storage; they are accumulating fuel for subsequent development of bodily heat energy. Side by side with starch, however, these unadvertised silent chemical agencies elaborate molecules even more imposing, in which nitrogen is interwoven with the elements of starch, and thus are produced the vegetable alkaloids.

* * * *

Micro-Biochemistry.

Amongst the many sources of pleasure to be found in contemplating the wonders of the universe, and denied to those untrained in scientific principles, is an appreciation of infra-minute quantities of matter. It may be urged by some that within the limits of vision imposed by telescope and microscope, ample material exists to satisfy the curiosity of all reasonable people, but the appetite of scientific inquiry is insatiable, and chemistry alone, organic, inorganic, and physical, offers an instrument by which the investigation of basal changes may be carried to regions beyond those encompassed by the astronomer and the microscopist.

It is not within the purpose of this address to survey that revolution which is now taking place in the conception of atomic structure; contributions to this question will be made in our later proceedings and will be followed with deep interest by all members of the Section. Fortunately for our mental balance the discoveries of the current century, whilst profoundly modifying the atomic imagery inherited from our predecessors, have not yet seriously disturbed the principles underlying systematic organic chemistry; but they emphasise in a forcible manner the intimate connection between different branches of science, because it is from the mathematical physicist that these new ideas have sprung. Their immediate value is to reaffirm the outstanding importance of borderline research and to stimulate interest in sub-microscopic matter.

This interest presents itself to the chemist very early in life and dominates his operations with such insistence as to become axiomatic. So much so that he regards the universe as a vast theatre in which atomic and molecular units assemble and interplay, the resulting patterns into which they fall depending on the physical conditions imposed by nature. This enables him to regard micro-organisms as co-practitioners of his craft, and the chemical achievements of these humble agents have continued to excite his admiration since they were revealed by Pasteur. The sixty years which have now elapsed are rich in contributions to that knowledge which comprises the science of micro-biochemistry, and in this province, as in so many others, we have to deplore the fact that the principal advances have been made in countries other than our own. On this ground, fortified by the intimate relation of the science to a number of important industries, A. Chaston Chapman, in a series of illuminating and attractive Cantor Lectures in December, 1920, iterated his plea of the previous year for the foundation of a National Institute of Industrial Micro-biology, whilst H. E. Armstrong, in Birmingham a few weeks later, addressed an appeal to the brewing industry, which, although taking the form of a memorial lecture, is endowed with many lively features depicting in characteristic form the manner in which the problems of brewing chemistry should, in his opinion, be attacked.

Lamenting as we now do so bitterly the accompaniments and consequences of war, it is but natural to snatch at the slender compensations which it offers, and not the least among these must be recognised the stimulus which it gives to scientific inquiry. Pasteur's *Etudes sur la Bière* were inspired by the misfortunes which overtook his country in 1870-71, and the now well-known process of Connstein and Lüdecke for augmenting the production of glycerol from glucose was engendered by parallel circumstances. That acquaintance with the yeast-cell which was an outcome of the former event had, by the time of the latter discovery, ripened into a firm friendship, and those who slander the chemical activities of this genial fungus are defaming a potential benefactor. Equally culpable are those who ignore them. If children were encouraged to cherish the same intelligent sympathy with yeast-cells which they so willingly display towards domestic animals and silkworms, perhaps there would be fewer crazy dervishes to deny us the moderate use of honest malt-liquors and unsophisticated wines, fewer pitiable maniacs to complicate our social problems by habitual excess.

* * * *

Photosynthesis.

Beyond a placid acceptance of the more obvious benefits of sunshine, the great majority of educated people have no real conception of the sun's contribution to their existence. What proportion of those who daily use the metropolitan system of tube-railways, for instance, could trace the connection between

their progress and the sun? Very moderate instruction comprising the elements of chemistry and energy would enable most of us to apprehend this modern wonder, contemplation of which might help to alleviate the distresses and exasperation of the crush-hours.

For many years past, the problem connected with solar influence which has most intrigued the chemist is to unfold the mechanism enabling green plants to assimilate nitrogen and carbon. Although atmospheric nitrogen has long been recognised as the ultimate supply of that element from which phyto-protoplasm is constructed, modern investigation has indicated as necessary a stage involving association of combined nitrogen with the soil prior to absorption of nitrogen compounds by the roots, with or without bacterial co-operation. Concurrently, the agency by which green plants assimilate carbon is believed to be chlorophyll, operating under solar influence by some such mechanism as has been indicated in a preceding section.

Somewhat revolutionary views on these two points have lately been expressed by Benjamin Moore, and require the strictest examination, not merely owing to the fundamental importance of an accurate solution being reached, but also on account of the stimulating and engaging manner in which he presents the problem. Unusual psychological features have been introduced. Moore's "Biochemistry," published three months ago, will be read attentively by many chemists, but the clarity of presentation and the happy sense of conviction which pervade its pages must not be allowed to deter independent inquirers from confirming or modifying his conclusions. The book assumes a novel biochemical aspect by describing the life-history of a research. The first two chapters, written before the experiments were begun, suggest the conditions in which the birth of life may have occurred, whilst their successors describe experiments which were conducted as a test of the speculations and are already receiving critical attention from others (e.g., Baly, Heilbron and Barker, Transactions of the Chemical Society, 1921, p. 1025).

It is with these experiments that we are, at the moment, most concerned. The earliest were directed towards the synthesis of simple organic materials by a transformation of light energy under the influence of inorganic colloids, and indicated that formaldehyde is produced when carbon dioxide passes into uranium or ferric hydroxide sols exposed to sunlight or the mercury arc lamp. Moore then declares that, although since the days of de Saussure (1804) chlorophyll has been regarded as the fundamental agent in the photosynthesis of living matter, there is no experimental evidence that the primary agent may not be contained in the colourless part of the chloroplast, chlorophyll thus being the result of a later synthetic stage. "The function of the chlorophyll may be a protective one to the chloroplast when exposed to light, it may be a light screen as has been suggested by Pringsheim, or it may be concerned in condensations and polymerisations subsequent to the first act of synthesis with production of formaldehyde" (p. 55). In this connection it is significant that chlorosis of green plants will follow a deficiency of iron even in presence of sunlight (Molisch, 1892), and that development of chlorophyll can be restored by supplying this deficiency, although iron is not a component of the chlorophyll molecule; moreover, green leaves etiolated by darkness and then exposed to light regain their chlorophyll, which is, therefore, itself a product arising from photosynthesis.

H. Thiele (1907) recorded the swift conversion of nitrate into nitrite by the rays from a mercury quartz lamp, whilst O. Baudisch (1910) observed that daylight effects the same change, and from allied observations was led (1911) to conclude that assimilation of nitrate and nitrite by green plants is a photochemical process. Moore found (1918) that in solutions of nitrate undergoing this reduction green leaves check the accumulation of nitrite, indicating their capacity to absorb the more active compound. Proceeding from the hypothesis that one of the organisms arising earliest in the course of evolution must have possessed, united in a single cell, the dual function of assimilating both carbon and nitrogen, he inquired (1918) whether the simplest unicellular algæ may not also have this power. He satisfied himself that in absence of all sources of nitrogen excepting atmospheric, and in presence of carbon dioxide, the unicellular algæ can fix nitrogen, grow and form proteins by transformation of light energy; the rate of growth is accelerated by the presence of nitrites or oxides of nitrogen, the latter being supplied in gaseous form by the atmosphere. From experiments (1919) with green seaweed (*Enteromorpha compressus*), Moore concluded also that marine algæ assimilate carbon from the bicarbonates of calcium and magnesium present in seawater, which thereby increases in alkalinity, and further convinced himself that the only source of nitrogen available to such growth is the atmosphere. A description of these experiments, which were carried out in conjunction with E. Whitley and T. A. Webster, has appeared also in the Proceedings of the Royal Society (1920 and 1921).

For the purpose of distinguishing between (1) the obsolete view of a vital force disconnected with such forms of energy as are exhibited by non-living transformers and (2) the existence in living cells of only such energy forms as are encountered in non-living systems, Moore uses the expression "biotic energy" to represent that form of energy peculiar to living matter. "The conception, in brief, is that biotic energy is just as closely, and no more, related to the various forms of energy existing apart from

life, as these are to one another, and that in presence of the proper and adapted energy transformer, the living cell, it is capable of being formed from or converted into various of these other forms of energy, the law of conservation of energy being obeyed in the process just as it would be if an exchange were taking place between any two or more of the inorganic forms" (p. 128). The most characteristic feature of biotic energy, distinguishing it from all other forms, is the power which it confers upon the specialised transformer to proliferate.

Conclusion.

In "The Salvaging of Civilisation," H. G. Wells has lately directed the attention of thoughtful people to the imperative need of reconstructing our outlook on life. Convinced that the state-motive which, throughout history, has intensified the self-motive must be replaced by a world-motive if the whole fabric of civilisation is not to crumble in ruins, he endeavours to substitute for a League of Nations the conception of a World State. In the judgment of many quite benevolent critics his essay in abstract thought lacks practical value because it underestimates the combative selfishness of individuals. Try to disguise it as one may, this quality is the one which has enabled man to emerge from savagery, to build up that most wonderful system of colonial organisation, the Roman Empire, and to shake off the barbaric lethargy which engulfed Europe in the centuries following the fall of Rome. The real problem is how to harness this combative selfishness. To eradicate it seems impossible, and it has never been difficult to find glaring examples of its insistence among the apostles of eradication. Why cry for the moon? Is it not wiser to recognise this quality as an inherent human characteristic, and whether we brand it as a vice or applaud it as a virtue endeavour to bend it to the elevation of mankind? For it could so be bent. Nature ignored or misunderstood is the enemy of man; nature studied and controlled is his friend. If the attacking force of this combative selfishness could be directed, not towards the perpetuation of quarrels between different races of mankind, but against nature, a limitless field for patience, industry, ingenuity, imagination, scholarship, aggressiveness, rivalry, and acquisitiveness would present itself; a field in which the disappointment of baffled effort would not need to seek revenge in the destruction of our fellow-creatures: a field in which the profit from successful enterprise would automatically spread through all the communities. Surely it is the nature-motive, as distinct from the state-motive or the world-motive, which alone can salvage civilisation.

Before long, as history counts time, dire necessity will have impelled mankind to some such course. Already the straws are giving their proverbial indication. The demand for wheat by increasing populations, the rapidly diminishing supplies of timber, the wasteful ravages of insect pests, the less obvious, but more insidious depredations of our microscopic enemies, and the blood-curdling fact that a day must dawn when the last ton of coal and the last gallon of oil have been consumed, are all circumstances which, at present recognised by a small number of individuals comprising the scientific community, must inevitably thrust themselves upon mankind collectively. In the campaign which then will follow, chemistry must occupy a prominent place because it is this branch of science which deals with matter more intimately than any other, revealing its properties, its transformations, its application to existing needs, and its response to new demands. Yet the majority of our people are denied the elements of chemistry in their training, and thus grow to manhood without the slightest real understanding of their bodily processes and composition, of the wizardry by which living things contribute to their nourishment and to their æsthetic enjoyment of life.

It should not be impossible to bring into the general scheme of secondary education a sufficiency of chemical, physical, mechanical, and biological principles to render every boy and girl of sixteen possessing average intelligence at least accessible by an explanation of modern discoveries. One fallacy of the present system is to assume that relative proficiency in the inorganic branch must be attained before approaching organic chemistry. From the standpoint of correlating scholastic knowledge with the common experiences and contacts of daily life this is quite illogical; from baby's milk to grandpapa's Glaxo the most important things are organic, excepting water. Food (meat, carbohydrate, fat), clothes (cotton, silk, linen, wool), and shelter (wood) are organic, and the symbols for carbon, hydrogen, oxygen and nitrogen can be made the basis of skeleton representations of many fundamental things which happen to us in our daily lives without first explaining their position in the periodic table of all the elements. The curse of mankind is not labour, but waste; misdirection of time, of material, of opportunity, of humanity.

Realisation of such an ideal would people the ordered communities with a public alive to the verities, as distinct from irrelevancies of life, and apprehensive of the ultimate danger with which civilisation is threatened. It would inoculate that public with a germ of the nature-motive, producing a condition which would reflect itself ultimately upon those entrusted with government. It would provide the mental and sympathetic background upon which the future truthseeker must work, long before he is implored by a terrified and despairing people to provide them with food and energy. Finally, it would give an unsuspected meaning and an unimagined grace to a hundred commonplace experiences. The quivering glint of massed

bluebells in broken sunshine, the joyous radiance of young beech-leaves against the stately cedar, the perfume of hawthorn in the twilight, the florid majesty of rhododendron, the fragrant simplicity of lilac, periodically gladden the most careless heart and the least reverent spirit; but to the chemist they breathe an added message, the assurance that a new season of refreshment has dawned upon the world, and that those delicate syntheses, into the mystery of which it is his happy privilege to penetrate, once again are working their inimitable miracles in the laboratory of the living organism.

OBITUARY.

T. N. Nacheapa Chetty.—Mr. T. N. Nacheapa Chetty, who was elected a Life Fellow of the Royal Society of Arts in 1915, died at his residence in Ramachandrapuram, Pudukotah State, South India, on July 21st. He was born in 1841, and on leaving school he entered his father's business as a banker. He travelled extensively throughout India, Burma, the Straits Settlements and Ceylon studying the systems of business adopted in these parts, and he thus acquired an intimate knowledge of banking methods, with the result that he amassed a large fortune. In addition to this work he may also be said to have been the pioneer of the cloth trade in the Straits Settlements.

Mr. Chetty was an enlightened and practical social reformer, and he devoted large sums of money to charitable and religious objects. He was deeply respected by all who knew him, and he did good service as an ardent supporter of the Panchayat system—a board of elected representatives sitting as arbitrators or judges and deciding all matters of dispute arising among members of the community.

Sir William Edward Garforth, LL.D., M.Inst.C.E.—Sir William Garforth, who was elected a Fellow of the Royal Society of Arts in 1920, died suddenly at his residence, Syndale Hall, Pontefract, on the 1st inst., at the age of 75. The son of William Garforth, of Dunkinfield, Cheshire, he was well known as a mining engineer, and was a Past President of the Mining Association of Great Britain, President of the Institution of Mining Engineers, and Chairman of the Mining Committee of the University of Leeds. In 1911 the Council of the Royal Society of Arts awarded him a gold medal under the Fothergill Trust "in recognition of his efforts to perfect and to secure the adoption of rescue apparatus in mines." He also received the first medal of the Institution of Mining Engineers, and was Vice-President of the jurors at the Brussels Exhibition of 1910. He was knighted in 1914.

BEESWAX.*

Wax is organically produced in the body of the worker bee from honey and pollen, by secretion. It is formed voluntarily by the bees filling their stomachs with honey, hanging in the hive in chain-like clusters, and remaining perfectly quiet for twenty-four hours. A good deal of pollen is consumed to make up for the wear and tear of tissue during wax secretion. During this period the wax glands convert the honey taken into their bodies into liquid wax which exudes through tiny perforations into eight small pockets, or moulds, situated on the underside of the last four abdominal segments, where it hardens into small white scales. It is then plucked out, made plastic by the admixture of saliva, and utilised for the building of the comb, the hermetic sealing of honey cells, and, with the addition of pollen, for the porous sealing of brood cells. It is computed that from 10 to 20 lb. of honey are required to make 1 lb. of wax. The work of wax secretion tells severely upon the vital powers of the bee, and as wax is a valuable and costly product, none of it should be wasted.

How to Collect Wax.—When cleaning hives or appliances, a box should be kept for the collection of all refuse and burr combs. The scrapings from the floor board, which are generally thrown on the ground during spring cleaning, should be saved, although they contain a quantity of dirt and propolis, for there is generally sufficient wax to make it worth the trouble of collection and extraction. The honey combs used for extracting do not wear out, but last indefinitely; brood combs, on the contrary, become thickened by the cocoons and cast skins of the moulting larvæ, and must be continually renewed. Wax can, therefore, be obtained from old brood combs and the cappings from extracting combs.

Methods of Extraction.—The extraction of the wax may be made by using: (1) The Solar Wax Extractor; (2) steam; (3) boiling water; or (4) the heat of the oven.

The Solar Wax Extractor is the most efficient and economical method. The cost of the extractor is the only expense incurred, as the sun provides the necessary heat. The appliance is really a miniature garden frame, with a double glazed and hinged light. Inside, the frame is fitted with a metal tray which slopes down to a tin trough covered with wire gauze. The extractor is placed in a sunny position and the material to be treated is spread thinly over the bottom of the metal tray. The wax melts and runs into the trough, being strained of impurities by the wire gauze covering. When the melted wax ceases to flow, the dross remaining in the tray is removed and a fresh supply of material given. Another advantage of this

* Extracted from a Leaflet published by the Ministry of Agriculture and Fisheries.

extractor is that no storage of old conbs or refuse is necessary; these can be put in for treatment as collected.

If a garden frame is available, it can be used for extracting wax by placing the material to be treated in a perforated zinc tray over a metal box (such, for instance, as a biscuit tin), placed close up to the glass light. Wax extracted by solar heat improves in colour instead of deteriorating, as it may do when steam or boiling water is used.

Steam.—The material to be extracted by methods (2) and (3) must be stored until required in an air-tight tin, for protection against the ravages of the wax moth. In the winter it can be melted over the kitchen fire by means of a Gerster wax extractor.

This is an arrangement similar to a domestic steamer. It consists of a cylindrical, perforated, tin basket, having a cone-shaped tube running up the centre which is also perforated, and open at the top to allow the steam to percolate right through the combs or wax that are placed in it for melting. The upper part of the appliance consists of a circular-shaped pan, having a false bottom or tray about 1½ in. deep. This is fixed so that there is a space between it and the wall of the pan, in order that the steam can pass up the sides and into the perforated basket.

From this tray the melted wax passes through a tube. There is also a cone-shaped tube running up from the tray, which fits very loosely into a similar perforated tube in the basket. When placed in position this is open at the top to allow the steam to pass through and thus permeate the wax or combs in the basket. The basket does not fit close down on the tray, but is raised about 1 in. on three legs. The bottom pan is for water only.

The method of working is as follows:—The perforated basket is filled with comb which has first been broken into small pieces; these should not be pressed down, but put in as loosely as possible. The basket is placed in position in the pan and covered with the lid. The pan is now fitted on a second pan, which has previously been filled with rain water. The appliance is then put on the fire, and when the water boils the steam will melt the wax from the combs in the perforated basket. The molten wax will ooze out through the perforations, run down the sides of the basket into the tray, and thence out of the tube, where it drops into cold rain water, contained in a vessel placed for the purpose of receiving it. As soon as it is cold, the wax will be found to have set in a cake, when it can be lifted off. When all the wax has been extracted the dross is removed from the basket and the process repeated.

As the water boils away very rapidly it will be necessary to replace it from time to time; by means of a funnel this can be done without removing the appliance from the fire.

Cappings from the shallow combs, when cut off for extracting the honey, can also be melted in the same manner. Before putting them in the basket, however, they should be drained free from honey, well washed in rain water, and dried in the sun.

Boiling Water.—To extract wax by means of boiling water, the material should be tied in a bag made of porous fabric, such as cheese straining cloth, and placed on laths of wood crossing the bottom of a copper or saucepan, so that the bag does not touch the bottom. The bag should be weighted with a stone, and water then poured in until it flows above the bag. The melted wax will percolate through the bag and float on the water, and when cold it can be lifted off in a solid cake. A little dross will be found on the bottom of the cake, but this can be removed by scraping. If a well-cleansed sample is desired, the cake should be remelted in a similar manner, and cooled slowly. Rain water must be used in methods 2 and 3, as hard water contains lime, which would spoil the texture and colour of the wax. More wax will be obtained if pressure is applied to the bag while boiling, and in the case of old combs, if these are well soaked in water previously to melting.

The Heat of the Oven.—If only a small quantity of wax is to be dealt with, it may be placed on a piece of perforated zinc over a bowl of rain water, and put in the oven. The wax will melt and drop through the perforated zinc into the water; the impurities will remain on the zinc and can be thrown away. The bowl is then taken out of the oven and the water and wax allowed to cool, when the latter will have set in a cake and can be lifted off.

Characteristics of Pure Wax.—The melting point of pure beeswax is between 63° and 64° C., which is a higher than that of any other wax. The colour, which varies from pale primrose to orange red, depends to a great extent upon the variety of pollen consumed by the bees. It is a curious fact that dark honey produces a light wax, while light honey yields one of a darker hue.

For commercial purposes the lightest coloured wax commands the best price, and, therefore, before extracting, it is advisable to grade the combs. Those which have not been occupied by brood, and also cappings removed from combs previous to extracting the honey, will yield the best wax, and should be sorted out and melted separately from old combs, which will yield a darker and consequently less valuable wax.

Adulteration.—The following are simple tests for detecting adulteration of beeswax:—

(1) A small piece of wax placed in the mouth and chewed should not adhere to the teeth, or become pasty, but, generally speaking, should disintegrate into small fragments, and have no unpleasant taste.

(2) Place a piece of suspected wax (of the size of a small nut) into a test tube, half fill with spirits of turpentine, and carefully warm over the flame of a spirit lamp. If the solution is cloudy, or a deposit is thrown down, the solution is not complete, and the wax is adulterated, as spirits of turpentine completely dissolve pure beeswax.

EXPERIMENTS IN ROAD-MAKING AT NICE.

Some interesting experiments in road-making are now being made near Nice, at Lagnes, a village on the great highway to Marseilles, just beyond the bridge over the Var, a spot much frequented by automobiles. A length of about 2 kilometres (1¼ miles) is being relaid with a new composition called *Siliditit*, a kind of concrete, the speciality of a French Company, "La Siliditit Française." The work is being executed under the supervision of the engineers of the Ponts et Chaussées. The substance used differs somewhat from the ordinary concrete, being not merely a mixture of the siliditit with the ballast, but rather a chemical combination. The mass thus obtained is essentially a new compound, instead of a simple mixture, as is the case when Portland cement and ordinary ballast are used.

This new material, patented about 10 years ago in Italy, and known in France somewhat more recently, contains certain ingredients obtainable principally in Italy, including quartz, felspar, etc., which are embodied in the special cement called Siliditit. It is the mixture of hese substances, with water, which gives to the new material its special degree of hardness. When the roadway has been properly prepared, a layer of ordinary concrete (ballast and Portland cement) 15 centimetres (6 inches) deep is first laid and well rammed and rounded to form the shape of the road. Before this has completely set, a layer of the new material, 4 centimetres (about 1⅝ inches) deep is spread over and well rammed with specially designed rammers worked by compressed air, at a pressure of 6 atmospheres, which gives about 400 blows per minute. This is afterwards smoothed down by a steam roller, and in less than 48 hours, the new road is ready for use.

The advantages of this new system are greater cohesion of the mass, cleanliness, and greater resistance to compression. Should the experiment prove successful, it is intended to try the material on about 10 kilometers (6 miles) on the road to Monte Carlo, where its freedom from dust, etc., will prove a great advantage.

Another experiment of the same kind is being made on the main road between St. Etienne and Lyons.

GENERAL NOTE.

Department of Scientific and Industrial Research.—A special series of Reports is being published for the Department of Scientific and Industrial Research in order to make available for the benefit of the industries concerned results of scientific and industrial value contained in the Technical Records of the Department of Explosives Supply of the Ministry of Munitions. The work recorded was done at or in connexion with some of the National Factories during the war. The preparation of the necessary abstracts and information was begun by the Ministry of Munitions at the close of the war and arrangements have recently been made by the Department of Scientific and Industrial Research to complete them. The first Report in this series, "Recovery of Sulphuric and Nitric Acids from Acids used in the Manufacture of Explosives, Denitration and Absorption," has already been published by H.M. Stationery Office, from whom copies may be obtained, price 12/6 (by post 13/-). The present Report "Manufacture of Trinitrotoluene (TNT) and its Intermediate Products" is divided into the following sections:—Section I. History of Manufacture. Section II. Plant and Process for the Manufacture of TNT. Section III. Plant and Process for the manufacture of 2 : 4—Dinitrotoluene.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

Monday, October 17th.. East India Association, 7, Tothill Street, Westminster, S.W., 3.45 p.m.

Tuesday, October 18.. London County Council. At the Royal Society of Arts, John Street, Adelphi, W.C., 6 p.m. Lecture to Teachers, by Sir H. J. Mackinder.
Zoological Society, Regent's Park, N.W., 5.30 p.m.

Wednesday, October 19.. Ingénieurs civils de France, Société des (British Section), at the Institution of Mechanical Engineers, Storey's Gate, S.W. 1, 8 p.m. "Tanks and Chain-Track Artillery," Mr. L. A. Legros, M.I.C.E., M.I.M.E., M.I.E.E., M.I.A.E.
Microscopical Society, 20, Hanover Square, W., 8 p.m. 1. Dr. Lancelot T. Hogben, "Preliminary Account of the Spermatogenesis of Sphenedon." 2. Mr. Dan M. Stump, "An Application of Polarized Light to Resolution with the Compound Microscope."
United Service Institution, Whitehall, S.W., 3 p.m. Mrs. Nesta Webster, "Bolshevism and Secret Societies."

Thursday, October 20.. Aeronautical Society. At the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Mr. G. Brewer, "The Langley Machine and the Hammondsport Trials."
Chemical Society, Burlington House, W., 8 p.m.

Friday, October 21.. Transport, Institute of, at the Royal Society of Arts, John Street, Adelphi, W.C., 5 p.m. Mr. Salt, "Water Transport—Coastwise Shipping of the United Kingdom."
Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Eleventh Report of the Alloys Research Committee, by Messrs. W. Rosenhain, S. L. Archbutt and D. Hanson.

Announcements intended for insertion in the above list must be received at the Society's Office not later than the Monday of the week preceding the meeting.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RECENT APPLICATIONS OF THE SPECTROSCOPE AND THE SPECTROPHOTOMETER TO SCIENCE AND INDUSTRY.

By SAMUEL JUDD LEWIS, D.Sc., F.I.C., Ph.C.

LECTURE II.—*Delivered April 18th,* 1921.

In the first lecture we considered recent work in those branches of spectroscopy, which are familiar to the majority of those engaged in the science. We have now to make brief reference to three branches which are not so well known to the average worker.

First, we will consider the *vacuum tube spectra* of the late Dr. James H. Pollock, of Dublin. This subject had received very little attention since the researches of Plücker and Hittorf in 1864. (Phil. Trans. 155, 1865, 1-29.) Pollock found that much had to be done to improve the method into something practical and accurate. Indeed, he found that the earlier work was merely of a preliminary character, and that nearly all the details which make for successful experiment had yet to be discovered. His researches related to compound substances such as metallic chlorides which could be volatilised at a high temperature in a vacuum; and the ultimate object was to study the banded spectra of such compounds (Sci. Proc. Royal Dublin Soc., 1912, 13, 202-218 and 253-268).

Banded spectra originate usually in the molecules of compounds in a state of vapour, whereas *line spectra* result from movements of the electrons within the structure of the atom of an element which is exhibited in the state of incandescent vapour.

The apparatus used by Pollock is shown in Fig. 4, and his method of experiment was as follows:—

He employed a quartz tube consisting of two bulbs connected by a capillary. In the lower bulb, 0.05 gm. of the substance is placed; a glass stopper, carries the negative electrode and is joined to the lower bulb, by a rubber connection; a small tube, provided with a stop-cock, connects the other end of the charged tube with a vacuum pump, and in its upper end is sealed the positive electrode.

After evacuation, the lower bulb and the capillary are heated by a Meker burner and the condensed discharge from a large coil used for producing the luminescence. The slit of the spectrograph is applied to the capillary just as for ordinary gas-tube observations.

Unfortunately, this able and untiring worker passed away in 1915, leaving the main investigation almost untouched. He showed, however, that when large quantities of vapour are evolved, bands characteristic of the compound molecules are generated, and that under certain other conditions line spectra of the constituent elements appear. His extensive preliminary researches led him to summarise the results in the following words: "That in many of the spectra, especially when much vapour is present, and no Leyden jar is used, very beautiful bands develop, some of which are entirely new to science, and these will require further study before any general conclusion can be drawn regarding them. They are quite independent of the lines of the spark spectra of the elements and probably owe their origin to the molecules of the compounds under observation."

So far there is little evidence of others following in his steps, but his path is one

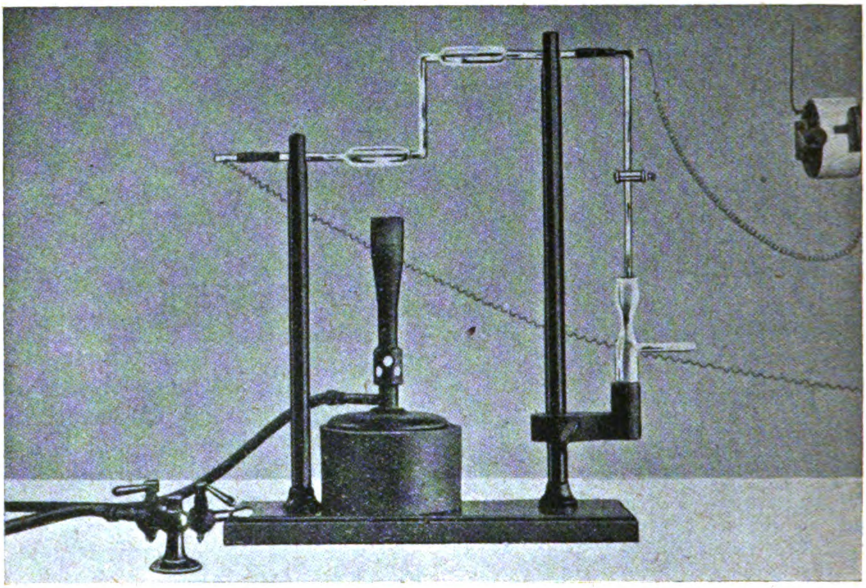

FIG. 4.

leading to very wide fields for exploration.

Secondly, during the past few years great efforts have been made by a few enthusiastic workers, especially Schumann, Lyman and McLennan, to explore the extreme ultra-violet regions of the spectrum. In conducting these investigations, two difficulties presented themselves; first the necessity of devising special photographic plates, such as will avoid the absorption of the rays of very short wave-length by the gelatin or other medium in the film, and, secondly, the necessity of eliminating air, for air is opaque to these very short vibrations.

To meet these requirements vacuum spectrographs have been designed, and of these there are two or more classes. In one of them the instrument differs very little from the quartz spectrograph already described, except that the optical parts are made of fluorite instead of quartz, and that the whole space concerned in the experiment, including that for accommodating the arc or spark lamp, is highly evacuated. In particular, it is rendered specially free from oxygen by repeatedly washing out with hydrogen, and from every trace of moisture by the inclusion of a tray of phosphorus pentoxide. (McLennan, Ainslie and Fuller, of Toronto; Proc. Royal Soc. A., 95, 1919, 316-332.)

Another class of vacuum spectrograph avoids the use of refractive media, such as quartz or fluorite. The essential parts of the apparatus are all enclosed in a metal cylindrical chamber, in which a high vacuum and freedom from moisture can be maintained as described before. The spectrum is produced by a curved grating at one end of the chamber directed towards two slits at the other; the two slits avoid the necessity of adjusting the grating for the various parts of the spectrum; the ranges covered by the slits are approximately for wave-lengths 2100 to 1200 and 1200 to 500. (McLennan and Lang; Proc. Royal Soc. A. 95, 1919, 258-273.)

By such means the extreme ultra-violet region of the spectrum has been extensively explored and much good work has been done. Arc and spark spectra of several elements have been mapped, among which may be mentioned H, He, C, Zn, Ca, Hg, Pb, Tl, Sn, Co, Ni, Fe, Al.

A great consequential result has also been achieved, namely, to show that the positions and characters of the lines harmonise with the theory relating to series of lines in spectra; but a discussion of this is outside the scope of these lectures.

Thirdly, in reviewing the history of spectroscopy, one becomes conscious of the progress of the science being punctuated by the advances made in means of illumination. The earliest observations of the spectrum were made with sunlight. Then, during the first year or two of the 19th century, flames of alcohol in which various substances were dissolved claimed attention,

followed by the blow-pipe flame projected from a spirit or oil lamp. In those days coal gas was rarely available, and it was not until 1857 that the well-known Bunsen burner was introduced and applied to that historic work in spectroscopy by its inventor and Kirschoff. In the meantime, Wheatstone, in 1834, applied the electric spark, and Bunsen, in 1840, the arc; but these luminants were derived from laboratory apparatus. In 1886, Hartley in his lecture here welcomed the greatly increased facilities afforded by the then recently installed electricity services.

Another nine years elapsed before the discovery of X-rays by Röntgen in 1895, and again some considerable time before it was shown that in nature they were merely light of extraordinarily short wave-length. Still another decade passed, before they were marshalled into a spectrum, so that even now it is but yesterday since the first observation of an X-ray spectrum.

The long delay between the recognition of X-rays and the production of a spectrum was due to difficulty of making a grating sufficiently fine to effect their diffraction. The open spaces in a Rowland grating with even 25,000 lines to the inch, that is, 100 lines to the mm., are wide avenues for X-rays. with wave-lengths of only one ten-millionth of a millimetre. Eventually in 1911 Dr. Laue, of Zurich, conceived the idea of using the ordered arrangement of atoms or molecules in a crystal as a natural grating sufficiently fine to produce a spectrum of X-rays in much the same way as an ordinary grating gives rise to the ordinary spectrum. In 1912 Friedrich and Knipping put the idea to practical test by interposing a thin plate of zinc blende in a narrow pencil of X-rays proceeding from the anticathode of an X-ray bulb to a photographic plate. The crystal structure was thus used as a transmission grating, and with this they obtained a photographic impression on the plate of a central primary beam surrounded by a number of small spots; this corresponds with the primary beam through an ordinary grating and the feeble diffraction images forming the spectrum on either side. But Professor Bragg soon applied the crystal as a reflection grating, and in this form it is usually used in the study of X-ray or high frequency spectra. The most brilliant work in this field is due to the late Mr. H. G. J. Moseley in 1913 and 1914 (Phil. Mag. 26, 1913, 1024-1034; 27, 1914, 703-713.)

For a detailed description of the apparatus which he used reference should be made to the original papers. The significant details were that the anticathode or "target" in the focus tube was composed of the element or elements to be investigated and that the X-rays projected therefrom fell on a crystal of potassium ferrocyanide which served as a reflection grating with the production of a spectrum which imparted an image to a photographic plate.

It was not surprising that the spectrum thus photographed possessed characters which are physical constants of the elements in the target, but the spectrum of each element was novel in that it exhibited only a very small number of very well defined lines, such as 2 or 3 or 5, with a continuous spectrum as a background, as shown in the Fig. 5 which is taken, by permission, from Moseley's paper.

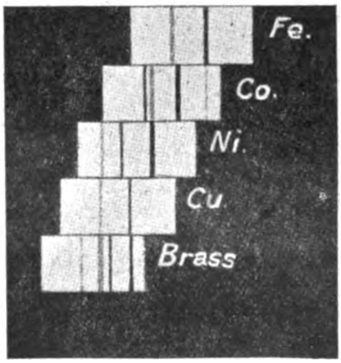

Fig. 5.—X-ray spectra of some of the elements. Note the faint lines in the cobalt spectrum. One coincides with an iron line above, the other with a nickel line below, showing that the cobalt contained these elements as impurities. In the x-ray spectrum of the "brass," two of the lines are due to copper, and the other two to zinc.

The wave-lengths of these lines were determined, and it was found when the square roots of their frequencies multiplied by 10^{-8} were plotted as abscissæ against the atomic numbers of the respective elements as ordinates that the points lay on straight lines, thus exhibiting a remarkable regularity. It is found that corresponding lines for the still unknown elements would make the scheme complete, and hence the X-ray spectra of these elements are known before the elements themselves are discovered. It follows that when the revelation of any one of them is suspected, its X-ray spectrum will determine whether it is real or not.

It is not improbable that X-ray spectra will some day find ready application to determining the composition of materials as do ordinary spectra, but they are already proving the means of the highest importance for the elucidation of crystal structure and similar subjects. For this, reference should be made to "X-Rays and Crystal Structure," by W. H. Bragg and W. L. Bragg.

We come now to consider spectrophotometry and absorption spectroscopy. Since the title of these lectures qualifies the scope by including the words "*Recent* applications," the new fields of absorption spectroscopy are found almost entirely within the boundaries of spectrophotometry.

Before proceeding to the discussion of details it will be of service to many to explain the principles of spectrophotometry.

Consider any spectrum which is actually continuous, or has so many lines evenly distributed in it, that for practical purposes it may be regarded as continuous. The spectrum may be characteristic of the light of any given lamp. Now place between the lamp and the slit of the spectroscope a film of some transparent substance. It will be found that the spectrum of the transmitted light is less intense than the original, either because the whole of the spectrum has been reduced uniformly in intensity, which is very rare, or because only certain parts have been reduced in intensity, while other parts have remained as before or only slightly affected.

Further, it will be seen that the region which is reduced in intensity has been affected more in some parts than in others. At one point, *i.e.*, at one wave-length, the reduction is only 10%, that is to say, 90% of the light has passed through the film; at another point, *i.e.*, at another wave-length, only one-fifth, or 20%, of the light has passed through, showing that four-fifths or 80% has been "absorbed;" and so on.

If now a measurement of the amount of light transmitted at every individual wave-length can be made, something of interest and significance may be discovered.

Such measurements constitute spectrophotometry, which differs from ordinary photometry in that any measurement refers usually to light of one particular wave-length only. The principles of experimental observation are the same as those in ordinary photometry, namely, (1) the method is one of comparison between a standard and the unknown; (2) the eye can determine equality or inequality, but it is not able to measure the degree of inequality; (3) the graduation of the intensity of the known factor till it is equal to the intensity of the unknown; or vice-versa.

The instrument adapted for such work is a spectrophotometer used in conjunction with a spectroscope or spectrograph. Thus, the spectrophotometer is an instrument for comparing the intensity of two rays of light of the *same* wave-length derived from different light sources, the rays having been dispersed and brought into juxtaposition in a spectroscope. By such means, we can say, for example, that one light is 1.56 times as strong as another light with reference to its component having a wave-length of 4537, but by the one observation nothing is learnt as to the comparison between the two lights for their components at any other wave-lengths.

The principle of the science and of the working of the spectrophotometer will be more readily appreciated by reference to an illustration.

The photograph reproduced in Fig. 6 shows several pairs of spectra. In each case the upper member is a normal spectrum of the light source, the lower is a spectrum of the same light after it has passed through a layer of the substance under examination; it is seen that much of the light has been absorbed. All the lower "absorption spectra" are identically the same, save only for time of exposure; but whatever that may have been, the time of exposure of its companion normal spectrum was the same, hence they are strictly comparable.

All the upper normal spectra are the same, except for intensity, also exposure, but the exposure is of no interest since it is the same as for its companion. The intensity of each normal band was adjusted accurately to the desired values by means of a spectrophotometer. These values expressed as percentages of the original intensity appear at the end of each band. It is then seen that the first pair of spectra are equal in intensity at wave-lengths of 2485, 2597, 2891, and since the whole of the normal band was adjusted to have an intensity equal to 22.16 per cent. of the original, it follows (1) that any one of its lines, and, therefore, the particular lines of 2485, 2597, 2891 wave-length, had an intensity of 22.16 per cent.; (2) that the

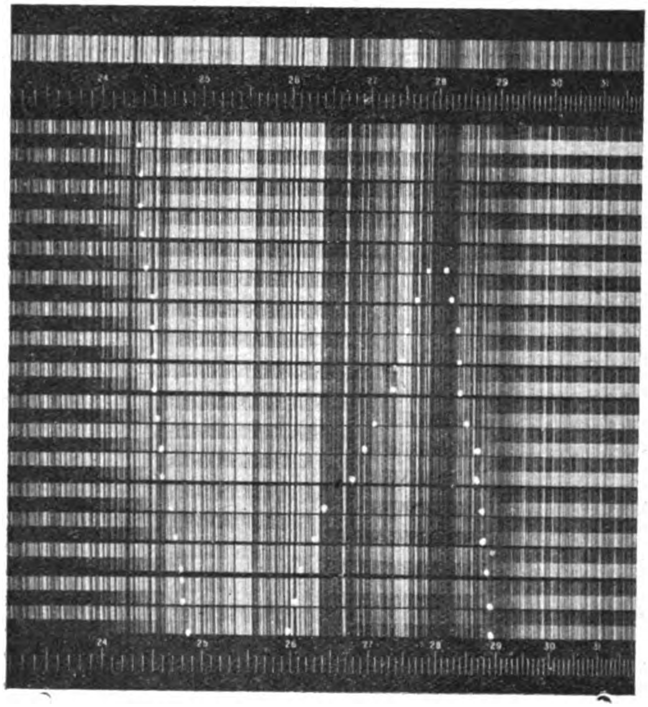

FIG. 6.—Absorption spectra.

lines of the *same* wave-lengths in the absorption spectrum also had an intensity of 22.16 per cent., since they are equal in the two bands. Hence 22.16 per cent. of the light of the given wave-lengths has passed through the substance and 87.84 per cent. has been "absorbed."

Similarly, points of equality in each of the other bands may be determined and tabulated

It has just been said that the percentage intensity of each band is determined by means of a spectrophotometer. Many instruments of this kind have been invented. Several depend on the use of polarising apparatus for quantitatively cutting down the intensity of the adjustable beam of light, but the introduction of polarising prisms limits their applicability to the visible spectrum only. The well-known Hüfner spectrophotometer and the Nutting photometer are instruments of this type, and have been applied very widely to the study of blood, dyes, etc.

The more difficult problem has been to devise some means of studying the ultra-violet region quantitatively. Many attempts have been made, but until recently nothing of importance appears to have been done, for in 1905 we find Kayser in his "Handbuch der Spectroscopie," Vol. III., p. 49, complaining that no truly quantitative method was known.

Hence, until 1914, the most generally approved method for determining the absorption spectrum of a substance in the ultra-violet region was that of Hartley, as modified by Baly. This consists in placing between the light source and the slit of the spectrograph a cell containing a solution of the substance to be examined, and taking a photograph of the absorption spectrum thus produced. The cell consists of the space between two parallel quartz plates, the distance between which is made adjustable, so that a layer of the liquid of any desired thickness may be examined

A series of photographs is taken, each with a prescribed thickness of the liquid. With the thickness or concentration for ordinates and the oscillation frequencies for abscissæ, the old absorption curves were drawn; or instead of the thickness, the logarithm of the thickness was plotted.

Under these conditions, most of the excellent work in absorption spectroscopy has been done, but this must all eventually give place to the more precise work to be done by spectrophotometry.

In 1914 the first suitable photometer appeared as the sector spectrophotometer, which was placed on the market by Messrs. Adam Hilger. With this much useful work has been done, and other instruments designed for the same class of work have already appeared.

It will be useful and most interesting to trace the development of the sector spectrophotometer during the last few years, to study the very different principles by which the same end is sought, and to see with what measure of success that end has been attained

As already mentioned, the Hilger instrument was the first and it appeared in 1914. Short descriptions of it are given by Lankshear in the Memoirs and Proceedings of the Manchester Literary and Philosophical Society (Vol. 58, No. 15, Part 3, pp. 1-12, 1914), and by H. E. Howe in the Physical Review for December, 1916 (pp. 674-688).

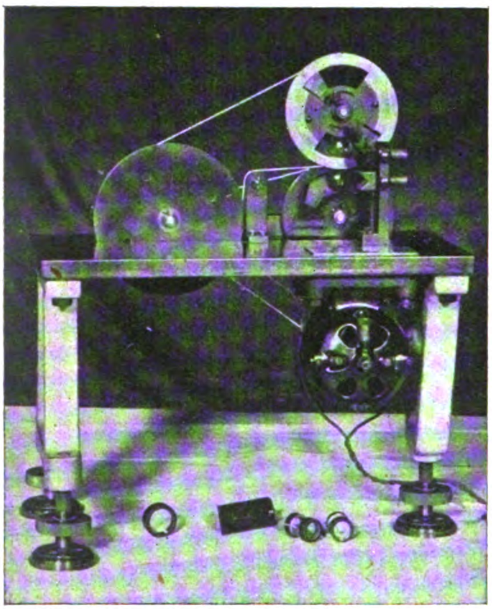

FIG. 7.

The form of the instrument is exhibited in Fig. 7, and its arrangement is shown diagrammatically in Fig. 8. It consists of two prismatic lenses, L_1, L_2, which focus the light from Q, on the slit S, of the spectrograph, and at the same time cause the two beams to converge on to a biprism, which is fitted close in front of the slit. The function of the biprism is to divert the beams so that they become parallel to one another and in juxtaposition in the spectrograph. In front of the lower lens is a sector D_1, which is merely a wheel, seen in side elevation in A, having in an annulus at a short radius from the centre, two apertures and two opaque portions each occupying a quadrant, of the form shown. In front of the upper lens is a similar sector wheel D_2 seen in side elevation at B, but in it is countersunk a concentric plate somewhat smaller in diameter and having similar apertures; the relative position of this plate can be so adjusted by moving it with the knob, H, about its axis and by fixing it with the clamping screw, J, that the opaque portion of its annulus covers any desired percentage of the aperture in the sector wheel; as illustrated in B. The position is determined by the index arrow, I, engraved on the smaller plate moving against the divided scale, G, engraved on the exposed rim around the face of the sector wheel.

Both sectors are kept in equally rapid rotation by means of a small motor during the period of observation. The effect is

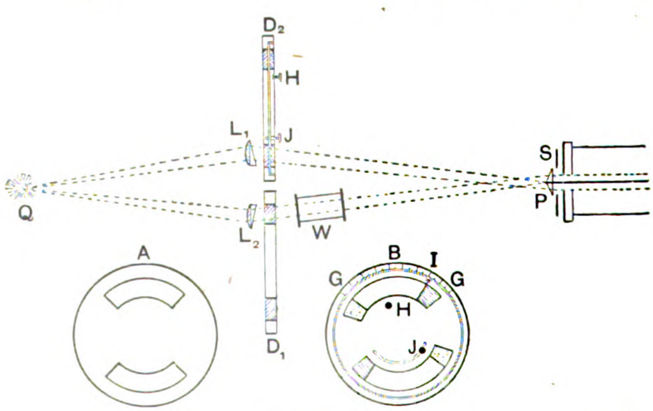

FIG. 8.

that the light passes through the lower sector into the spectrograph for a large number of exposures of given duration, while through the upper adjustable sector the light passes for an equal number of exposures which are similar, except that they are shorter, the duration being determined by the proportion of the original aperture left after the desired adjustment has been made. The intensity effect on the photographic plate in the spectrograph is approximately, although not precisely, proportional to the exposure, that is, to the size of the aperture in the sector.

The chief application of the instrument is to the study of absorption spectra, for which purpose the cell of substance under investigation, W, is placed in the path of light passing through the lower, fully open, sector.

A second photometer is due to Messrs. Bellingham and Stanley, Ltd. (1914). It is referred to in the paper on Blood Sera (loc. cit.), and also in a brief account given by F. R. Lankshear in the Memoirs and Proceedings of the Manchester Literary and Philosophical Society (Vol. 60, No. 10, pp. 1-4, 1916). The instrument has the appearance shown in Fig. 9, and its general arrangement is shown diagrammatically in Fig. 10. A pencil of light from the source, Q, is divided, and its parts brought together again by means of the right-angled reflecting prisms made of quartz, P_1, P_2, P_3, P_4, and focussed on the slit, S, by means of ordinary quartz lenses, L_1, L_2.

There is only one sector, in the position D,

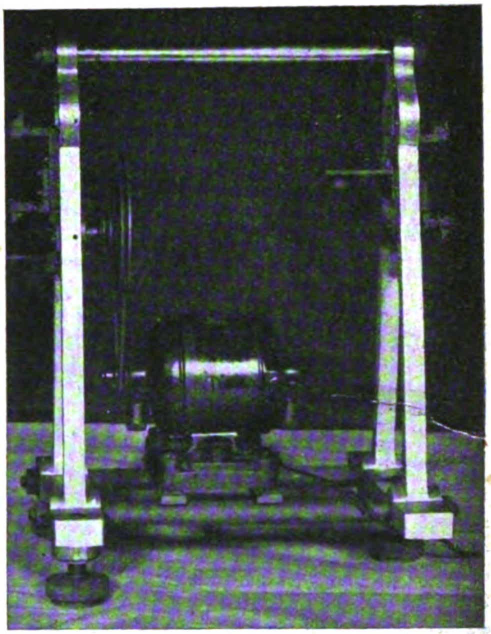

FIG. 9.

and that is different in both principle and construction from the others here described. It is also seen in front elevation at B. It consists of two concentric plates, A and C, the latter countersunk in the former, in each of which a concentric semi-circular aperture, *wx* and *yz*, is cut. The smaller plate is turned about the common axis by the knob H, and fixed in position relative to the other by the clamping screw, J, so as to form from edges of both semicircles

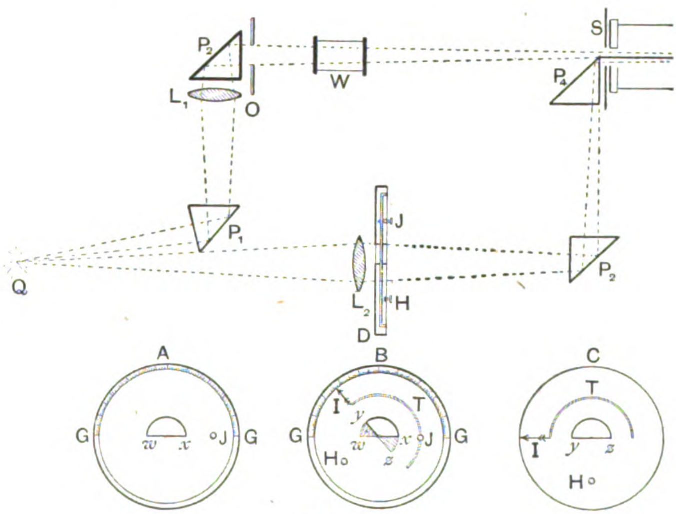

FIG. 10.

an aperture, xy, having the shape of a sector in the geometrical sense. The plate A is engraved with a scale divided into hundredths at GG, and the other plate C is engraved with the index arrow, I. The position of the index arrow with respect to the scale determines the percentage of the whole aperture which remains. The curved slot, T, serves merely to accommodate the clamping screw, J. In the other path of light there is a stop or diaphragm, O, which has an aperture of the same size as that of a whole semicircle in the sector.

During an observation the substance under examination is placed at W in the upper path of light, and the sector is kept rotating by an electric motor.

The two spectra are brought into juxtaposition by allowing both pencils of light to strike the upper edge of prism P_4, as shown in the diagram. Nearly the whole of the upper beam passes above the edge directly into the slit; what does fall on the face of the prism is reflected upwards out of the field. The main portion of the upward beam from prism P_3 penetrates the lower face of the prism P_4; but the direction of the light is so arranged that a small portion passes just outside the vertical face of prism P_4, so as to ensure the angle at the upper edge being filled with light.

The third new sector spectrophotometer was designed by myself in 1915, with a view to meeting the requirements of some researches on the ultra-violet absorption spectra of Blood Sera, for which the two earlier instruments had not proved adequate or sufficiently convenient in working. As will appear in the third lecture, in order to conduct the blood serum research efficiently, the conditions of rapid and reliable working and the simultaneous demand for precision were most exacting. No instrument can be unnecessarily refined for this, for if the ultra-violet absorption spectrography of blood sera or of anything else is to be applied clinically, the instrument must be both reliable for determining small variations and easy to manipulate. Incidentally an instrument which fulfils these conditions should satisfy most of the demands of scientific research and bring the practice of ultra-violet spectroscopy within the range of applied chemistry. Unless or until the ideals set out are attained, absorption spectroscopy can have little more than academic significance. Thus, as in many other cases, the perfection of the means is the key to the effective practice which is necessary for the advancement of science as well as technology.

Among the objects aimed at in the new design were :—The utmost precision wth a view to determining very small differences, rapid working, easy adjustment, and ready adaptibility to the spectrograph, so that the latter may be used alternately for other purposes.

A full description of this instrument illustrated by photograph and diagram was published in the Transactions of the Chemical Society, two years ago (p. 312-319), but as it has now been superseded by the new instrument to be described, no further reference to it will be made. However, nearly all the details there given apply equally to the later model and should be consulted for a full description of the sectors, etc.

The fourth and latest sector spectrophotometer is merely an improved form of the last, but it is an improvement in many details, and in this form it has been placed on the market by Messrs. Adam Hilger, Ltd. It is shown in Figure 11.

The photograph exhibits the general appearance of the new photometer. Its optical train is displayed in the diagram which is almost self-explanatory. It may be summarised by saying that a beam of light from the lamp, Q, is first divided into two beams falling on the fluorite-quartz combinations, L_1, L_2, by which they are rendered parallel. Considering the upper path only, the light passes through the face a_1b_1, in prism P_1, which is cut at an angle, so as to receive it perpendicularly, and allows its transmission to the reflecting surface a_1c_1, whence it reaches the surface b_1d_1, where it is again internally reflected as a parallel beam which passes through the sector D_1 and the observation cell W to the lens L_3, which focusses the light on the slit, the convergent beam being reflected at the surfaces e_1f_1 and g_1h_1 in prism P_3 and passed through the rhomb R. The lower beam passing through the lens L_2 is similarly treated. The lenses L_3 and L_4 move in sleeves graduated for focussing the light of any wave-length accurately on the slit, although this refinement is not often required, except when critically studying a given region of the spectrum.

This arrangement provides for perfect symmetry of construction, which commands

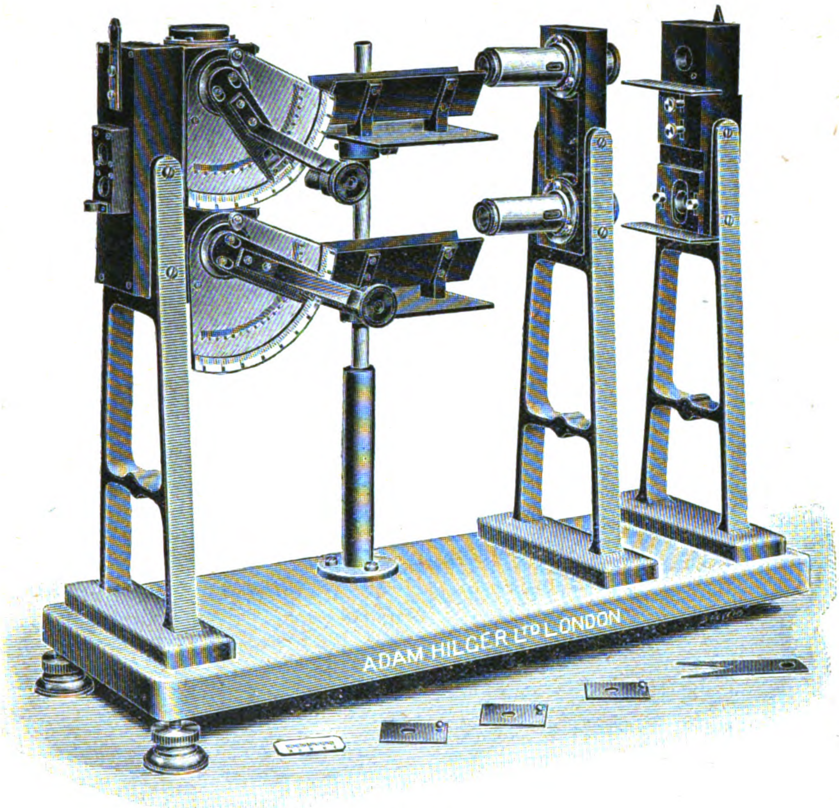
ADAM HILGER LTD LONDON

FIG. 11.

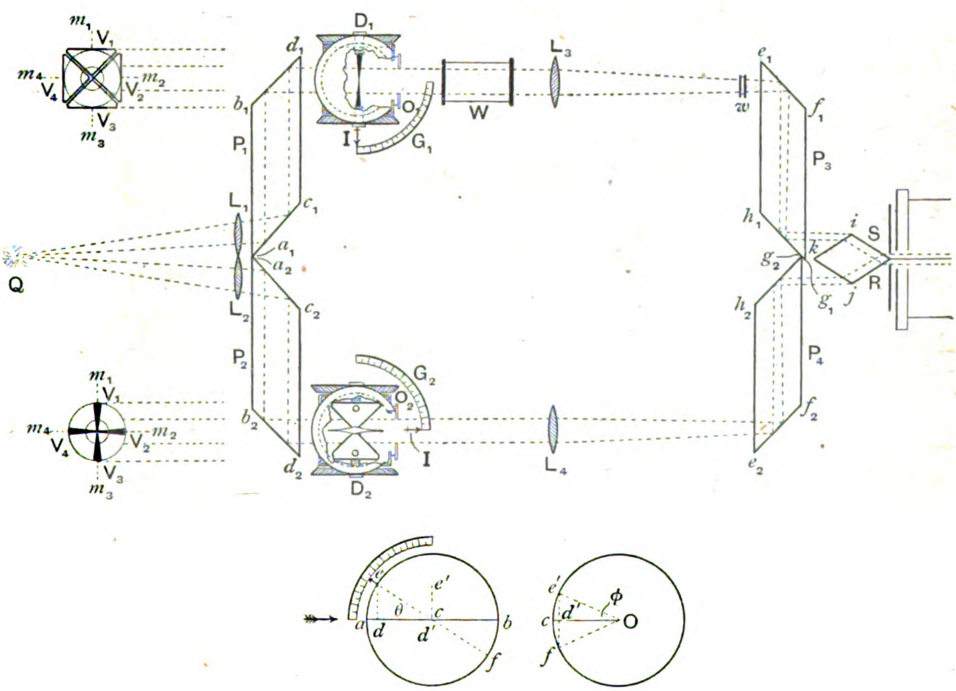
D1
d1
b1
P1
L1
c1
a1
a2
Q
L2
c2
P2
b2
d2
D2
O1
O2
G1
G2
I
W
L3
L4
w
e1
f1
P3
h1
g2
k
g1
h2
P4
f2
e2
i
j
S
R
m1
m2
m3
m4
V1
V2
V3
V4
θ
φ
O

FIG. 12.

equal treatment for the two beams of light as a prime factor, and for the desideratum that the light passing through the substance under investigation should be parallel.

The importance of the *simultaneous* use of the *same* light arises from two facts, namely, (1) that the light is never quite the same from time to time, (2) that the spectra from two lamps are never identical; their differences would appear as absorption effects.

The most distinguishing feature of the instrument is the design and operation of the sector, which is placed in a part of the path where the light is parallel. It consists of four vanes, V_1, V_2, V_3, V_4, as shown in the front elevation in Fig. 12. Each vane has two edges at right angles, and when the four vanes are disposed to one another in one plane, so that the four angles meet at a point, the system is closed and no light can pass. This arrangement is represented in the upper path in the figure. The common point of the four angles is on the optic axis, to which the plane is at right angles. Each vane can be turned by means of suitable mechanism about its bisector, m_1, m_2, m_3, m_4. When all the vanes are turned simultaneously through an angle of 90°, about their respective bisectors, light can pass in the direction of the optic axis without any interruption except that caused by the slight obstruction due to the thickness of the material of the vanes, as shown in the figure for the lower path. By turning the vanes through any other given angle about their bisectors, a known proportion of the light may be allowed to pass. Each of the four vanes is carried on a wheel, by means of a spindle which coincides with the bisector of the vane and also forms the axle of the wheel. These wheels are at right angles to one another, and are mounted in the walls of the box enclosing the sector, and fit into one another by bevelled cogs. They move simultaneously and the fitting is so close that back-lash is reduced to an insignificant minimum. The amount of rotation of the vanes is measured by a pointer mounted on the front wheel, and carrying a vernier, which, moving against the graduated quadrant, determines the movement to tenths of a degree, from 0° to 90°. A small magnifier moves with the vernier to assist the reading. When the sector system is open, and viewed along the optic axis, it simulates in appearance a Maltese cross. The obstruction or shadow produced by each vane has the form of a geometrical sector of known dimensions and, therefore, the sectional area of the pencil of light passing through the sector system is reduced by four times the area of one of the sector-shaped shadows; also, each of the four apertures has the form of a geometrical sector, so that the light is cut down in correct proportion from the centre to the circumference of the area, and not irregularly or from the periphery inwards, as with the iris and some other sectors. If the angle through which the wheel carrying the vane is turned is measured by θ, the angle subtended at the optic axis by the shadow of the vane is φ, and $\sin\theta = \tan\varphi$. The aperture is, therefore, $45° - \varphi$ and this measures the intensity of the light. This is illustrated in the two circles at the bottom of Fig. 12.

Among the advantages gained by this arrangement are (1) uniformity of illumination, as just described, (2) the whole of the aperture of the system is utilised, and not merely one half as in some other sectors; this shortens exposures to one half; (3) the light is continuous and not intermittent, and this avoids a common necessity for calibrating the photographic plates; (4) the sectors are still, and there is no need for the use of a motor or other mechanical contrivance; (5) the smaller apertures for the beam of light are reduced much more slowly than represented by the movement of the pointer, which imparts great precision to the smaller apertures; for example, a movement of the index from 80° to 80.5° decreases the aperture from 0.975 per cent. to 0.879 per cent., *i.e.*, 0.096 per cent., so that the delicacy is five times that of the movement of the pointer.

It will thus be seen that the three instruments are characterised chiefly by their sectors, which are distinguished not only in their construction, but also in the principles on which they operate. With the Hilger sector, reliance is placed on the principle that exposure and intensity of incident light are inversely proportional in their effect on the photographic plate, but the large number of rapid, short exposures introduces a defect, to correct which it is necessary to calibrate each batch of photographic plates against a standard.

With the Bellingham and Stanley sector, the gyration of the reduced beam of light around the optic axis, while the constant beam in the other optical train is stationary

and central on its optic axis, introduces an inequality of conditions which cannot be considered desirable.

The new instrument possesses in higher degree an advantage possessed also by the Hilger photometer, namely, that provision is made for eliminating the effect due to the presence of the solvent by placing a cell of the pure solvent in the other path of light. In this way, the effect observed is due entirely to the substance in the dissolved state, and hence its absorption curve is derived directly, instead of, under other conditions, by making correction for the effect of the solvent.

This remark draws attention to the possibility of the absorption spectrum of the substance in the state of mere solution being different from what it is when the solute is in chemical association with the solvent. Much work on this subject has been done, usually with a view to studying the effect of various solvents on the same substance.

Another aspect of the same subject has been studied by Purvis, who has worked with films of the substance *not* in the dissolved state, and hence determined differences caused by change of state. Several papers under his name will be found in the Journal of the Chemical Society.

It will be realised that the measurement of the light transmitted, in each part of the spectrum, and, therefore, of the light absorbed, requires to be conducted in some recognised way in order to arrive at results which are understood by all workers.

It is easy to conceive that for light of any given wave-length, it will be possible to discover some thickness of the material under examination which will absorb exactly nine-tenths of the light, that is, which will reduce the intensity of the light to one-tenth. The necessary layer may be very thick as for a clear substance like glass or quartz, or very thin as for a dense medium like glue. In any case, the reciprocal $\left(\frac{1}{d}\right)$ of that thickness (d) is known as the *extinction coefficient*, which is usually designated by ε. It is, however, rarely convenient to find its value by direct experiment, and so it is usually ascertained by using a layer of any suitable thickness (d') and measuring the intensity of the light transmitted (I') and calculating the extinction coefficient by the following formula:—

$$\varepsilon = -\frac{1}{d}\log. I'.$$

It is usual now when using the new photometers to express the light absorptive properties of a substance in terms of the extinction coefficient.

OBITUARY.

Sir George John Smith.—Sir George John Smith, who died at Treliste, Truro, on the 9th inst., at the age of 76, was a Fellow of the Society of long standing, having been elected in 1880. After being educated privately and at the University of London, he entered the firm of Messrs. Bickford Smith & Co.; in 1870 he became manager of the firm, and, on its conversion into a limited company, its Chairman. In 1918 it was amalgamated with other businesses as Explosives Trades, Ltd., and two years later its name was changed to Nobel Industries, Ltd.

Sir George took a deep interest in local administration. He was an original alderman of the Cornwall County Council, and for a long time Vice-Chairman of its Finance Committee. He was also a keen Volunteer, and later on, warmly supported the Territorial Scheme, becoming honorary colonel of the 4th Battalion, Duke of York's Light Infantry, which served in the war under the command of his eldest son, Lieut.-Col. G. E. Stanley Smith, D.S.O. A fine cricketer in his youth, he continued to support the game generously in his county. He was knighted in 1897.

NOTES ON BOOKS.

The Silk Industry of the United Kingdom. Its origin and development. By Sir Frank Warner, K.B.E. London: Drane, Ltd., 42*s*. net.

In its fluctuating fortunes at one time and another in various countries, the silk industry resembles many other industries. Sir Frank Warner's note at the opening of his work on the silk industry of the United Kingdom, tells us that it is impossible to estimate how far "disintegration and consequent lack of cohesion, unity of effort, political, economical, technical and educational, have led to the decline of the industry in this country." Nevertheless, it appears to have enjoyed a fairly good life recently, which it owes to the enterprise of such firms as Messrs. Courtauld, Messrs. Brocklehurst, Messrs. Warner & Sons, and many others too numerous to name here. Much also is owing to William Morris's influence on the artistic side which the late Sir Thomas Wardle seconded so well; and then holding a prominent position in the fortunes of the industry, are the

late Lord Masham's* achievements in perfecting combing machinery and greatly developing the treatment of waste silk. Hence the silk industry of the United Kingdom certainly appears to have properly risen to, and secured notable success as late as 1911, when Government Reports (Sir F. Warner quotes from them at pages 309 and 615) tell of the "magnificent display of British decorative and furniture silks at the Brussels and Turin Exhibitions," which "gained universal praise and the warmest expression of admiration from foreign experts and manufacturers." The war of course has interfered with trade, but has it extinguished the hope that the energy and patronage which have fostered the silk industry in the past, will again assert themselves for its future success ?

Sir F. Warner's History is a massive volume of over six hundred and fifty pages of letterpress accompanied by several attractive and well-produced illustrations; a few are in colours. The account of the beginnings of the industry in the United Kingdom starts with the period of the Norman Conquest—on slender and uncertain rather than firm foundations. For instance, we do not receive an impression of industrial activity in this country when we read that "Offa, King of Mercia, had a present of Silken Vests from the Emperor Charlemagne in 790," though the silk industry was then flourishing in the near East at Bagdad, Damascus, and Alexandria. Plate IV is a coloured facsimile of a page from a MS. in the British Museum, showing a woman weaving at a horizontal loom of the late fourteenth, if not the fifteenth, century; the date of the MS., however, is not given. This woman weaver is called "Primitive" but why primitive ? At that time there were thousands of weavers in Europe making far more elaborate stuffs, than the plain linen she appears to be weaving. However, these and other similar points which we need not specify now are perhaps trivial, though they may be worth correction in a future issue of the book.

A large part of the book consists of a compilation of well authenticated records of the Silk Industry as carried on in Spitalfields, in several large provincial towns, in counties like Norfolk, Essex, Kent, etc., also in Scotland, where the industry has had a longer and heartier career than in Ireland. Irish "Tabinet" or poplin weaving has had various ups and downs, and although it appeared to be getting into a better plight in 1913, the present conditions of the distressful country are not apparently over propitious to a renascence.

The latter half of the book deals with a number of topics such as *Silk from India*, *Waste Silk, its preparation for spinning and weaving*, several *Branches of Silk Weaving*: then come references to *Legislation* about silk manufacture—an early allusion to silk occurs in a Statute of Edward III.: *Trade Unions and Associations* and the *Smuggling Trade* conclude this section. The final chapters tell us of *Royal patronage* which has been conferred upon the industry and that "It was under Henry VI. that silk was first manufactured in England." The story of William Lee, the inventor of the mechanism for knitting, is fully given at pages 175 to 178 under Nottingham, it crops up under Trade Unions and Associations, page 487, and yet again at page 537 under Royal Patronage—in spite of Queen Elizabeth's having snubbed Mr. Lee's initial efforts. Royal Patronage is followed by some few pages on *The Weavers and other Kindred Livery Companies*. Then some account is given of the *Silk Association of Great Britain and Ireland*, the formation of which was largely due to the efforts of the late Sir Thomas Wardle, and of the Arts and Crafts Movement in which William Morris was the inspiring leader. Sir Frank Warner makes a very handsome acknowledgment of the work which has been done by the Royal Society of Arts from its very foundation in encouraging the Silk industry.

A warm welcome must be given to this excellent history of the industry by one whose family has been associated with it for generations and who has himself done so much to secure its revival in recent years.

*In 1886 Lord Masham was awarded the Albert Medal of the Royal Society of Arts for his services to the textile industries, "especially by the substitution of mechanical wool combing for hand combing, and by the introduction and development of a new industry—the utilisation of waste silk."

OSTRICH REARING IN SARDINIA.

The following account of Ostrich farming in Sardinia is taken from the *International Review of the Science and Practice of Agriculture*:—

An ostrich farm has been established at Baccarasa (in the Tortoli district, province of Cagliari), a locality situated to east of the Tortoli Arbatase railway, in a wide plain bounded on one side by the sea and on the other by the Ogliastra moutains. The site covering some 50 hectares, consists mainly of a deep, very permeable, sandy soil, covered with bushes of rock-roses and cork oaks. The birds are kept in enclosures in pairs or in groups, according to their age and the temperature. The enclosures are made by stretching iron wires 30 cm. apart on reeds planted vertically every 25 cm., and on juniper stakes spaces 3 m. apart. The height of the fence is about 2.5 metres and the enclosure has an area of 80 by 80 m. for pairs and more for groups. The enclosures are separated by paths planted with trees and each enclosure is provided with a house where the birds can shelter during bad weather and lay their eggs.

The houses are divided into two parts by a temporary partition; one part has a concrete floor, and the other is covered with a thick layer of sand in which the birds can dig a hole

50 or 60 cm. deep. The hen lays its eggs and hatches them, helped by the cock, in this second part. The cribs and watering places are placed around and inside the houses. A separate building contains the incubator room and that for rearing the chicks, both rooms being provided with means of heating and outside runs where the chicks can go during the warm hours of the day. The staff includes 3 agricultural labourers and 2 men who prepare and distribute the food. The incubator room and the chicks are looked after by the director's family.

A pair aged at least 2 years is chosen and isolated in an enclosure; the hen begins to lay at about the end of February and continues to lay until the end of June, one hen laying from 12 to 20 eggs in a season. Artificial incubation begins as soon as the first eggs are laid, as the season is still cold and renders natural incubation difficult. Towards the end of May or beginning of June, the eggs are left entirely to the care of the parents, who hatch out the eggs themselves.

About 60% of the eggs hatch, whether the incubation is natural or artificial, the former having no advantage over the latter, even as regards the strength of the chicks. Incubation lasts between 40 and 45 days. The most difficult period is that following on hatching, after which the ostriches are not subject to any disease, even of an infectious nature. They are affected by sudden changes in temperature, however, and they are consequently kept in their houses on rainy days or nights. They rarely suffer from indigestion, except when the temperature drops suddenly; the remedy consists in administering purgatives, particularly sulphate of magnesia dissolved in water.

The food varies according to the age, season, breeding and brooding time. The first meal is given 5 days after hatching, and consists of a mash of chopped raw meat, bone powder, and lucerne. The meat is gradually replaced by grains (wheat, barley, oats, maize), acorns, beans, chopped hay (especially lucerne), all kinds of grass, fruits of cactus (*Opuntia*), gourds, turnips, tubers, mulberry leaves, elm leaves, etc. During brooding and ovulation, a richer and more concentrated ration of forage is given. Dry or green forage must always be chopped up before being fed to the birds. The weight on hatching is about 1.5 kg., whilst the adult ostrich weighs about 100 kg., and stands 2.8 to 3 metres high.

At hatching, the plumage on the body is grey and striped in the direction of the length, with alternate light and dark bands, on the head and neck. The feathers at first aculeate, have longer vanes at 3 months. At one year, the male colours can be distinguished from those of the female:—the upper half of the neck and legs loses all the plumage or only retains a slight down; the black feathers grow on the body and the white feathers on the wings and tail. The females retain their grey colour. Gathering the feathers can be begun at an age of one year and a few months and is repeated each year in September and October. The method is as follows:—The ostrich is taken by the neck by means of a special iron hook, and two men hold it, taking care to avoid kicks (the only dangerous defence possessed by the ostrich), whilst another man cuts off the feathers 3-5 c.m. above the skin; 3 months after, the stumps are removed without pain by the ostrich itself and a month later, new plumes begin to appear.

The cock furnishes some 40 white and 40 black feathers, and the hen an equal number of grey ones. The first feathers that cover the body are not cut, but are collected when the bird moults. The largest white feathers are 50-60 c.m. long and 20-25 cm. wide, and the tail feathers are about half as long and wide as the wing feathers. The grey feathers of the female are the same length and breadth as the corresponding feathers of the male.

MEETINGS OF OTHER SOCIETIES FOR THE ENSUING WEEK.

MONDAY, OCTOBER 24.. University of London, King's College, Strand, W.C., 5.30 p.m. Dr. R. W. Seton-Watson, "History of Austria-Hungary, 1526-1867." (Lecture I.)

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Graduates' Meeting.) Mr. R. E. Light, "The Efficient Utilization of Steam and Electric Power in Factories."

East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Rev. F. Oldrieve, "The Leper Problem in India and the Treatment of Leprosy."

TUESDAY, OCTOBER 25.. Sociological Society, 65, Belgrave Road, S.W., 8.15 p.m. Mr. Raymond Unwin, "Preparations for the General Adoption of Town Planning."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Mr. T. F. McIlwraith, "The Influence of Egypt on African Death Ceremonies."

WEDNESDAY, OCTOBER 26.. Sociological Society, 65, Belgrave Park, S.W., 6 p.m. Mr. H. J. E. Peake, "The Evolution of the Village Community in England: an Anthropological Interpretation." (Lecture I.)

Literature, Royal Society of, 2, Bloomsbury Square, W.C. 5 p.m. Mr. S. Cooper, "A Fresh Light on Shakespeare Sonnets."

THURSDAY, OCTOBER 27.. Mechanical Engineers, Institution of (Midland Branch), The University, Birmingham, 7.30 p.m. Mr. A. G. Engholm, "Heating Buildings and Steamships." (North Western Branch), Memorial Hall, Albert Square, Manchester, 7 p.m. Mr. C. Day, "Inaugural Adddress."

China Society, at the School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Mr. G. Willoughby Meade, "Chinese Arts and British Fashions."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., at 5.30 p.m. 1. Mr. Leonard Hill, "Ventilation and Human Efficiency." 2. Mr. J. N. Justice, "Notes on the Ore Deposits of Eagle Mountain, Demerera."

FRIDAY, OCTOBER 28.. Cyclist Touring Club, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6.30 p.m.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Discussion on the Eleventh Alloys Report.

THE LIBRARY.

The following books have been presented to the Library since the last announcement. Except where otherwise stated they have been presented by the publishers:—

Aitchison, Leslie, D.Met., B.Sc.—Engineering Steels. London: Macdonald and Evans, 1921.

Baker, Richard T., and Henry G. Smith, F.C.S.—A Research on the Eucalypts and their Essential Oils. 2nd edition. Sydney: W. A. Gullick, 1920.

Bolas, Bernard D.—Laboratory Glass-Blowing. London: George Routledge and Sons, Ltd., 1921.

Caven, R. M., D.Sc., F.I.C.—The Foundations of Chemical Theory. London: Blackie and Son, Ltd., 1920.

Crook, Thomas.—Economic Mineralogy. London: Longmans, Green and Co., 1921.

Cundall, Frank, F.S.A.—Handbook of Jamaica, London: Edward Stanford, Ltd., 1921. Presented by the Compiler.

Cunningham, E., M.A.—Relativity and the Electron Theory. Second Edition. London: Longmans, Green & Co., 1921.

de Villamil, Lt.-Col. R.—Soaring Flight. London: Charles Spon, 1920.

Doorly, Eleanor, M.A.—England in her Days of Peace. London: George Philip & Son, Ltd., 1921.

Evans, Elliott A., F.C.S.—Lubricating and Allied Oils. London: Chapman & Hall, Ltd., 1921.

Evans, George.—The Old Snuff House of Fribourg and Treyer, 1720-1920. London: 1921.

Fairgrieve, J., M.A., & E. Young, B.Sc.—The Gateways of Commerce. London: George Philip & Son, Ltd., 1921.

Fleming, J. A., M.A., D.Sc., F.R.S.—Fifty Years of Electricity. London: The Wireless Press, Ltd., 1921. Presented by the Author.

Gage, Prof. Simon Henry.—The Microscope. Ithaca, New York: The Comstock Publishing Co., 1920. Presented by the Author.

Gough, George W., M.A.—Wealth and Work. London: George Philip & Son., Ltd., 1921.

Haynes, Edwin.—Timber Technicalities. London: William Rider & Son, Ltd., 1921.

Huntington, Ellsworth & Sumner W. Cushing—Principles of Human Geography. New York: John Wiley & Sons. London: Chapman & Hall, Ltd: 1921.

Kellor, Frances.—Immigration and the Future. New York: George H. Doran Co., 1920.

Knowles, L. C. A., Litt.D.—The Industrial and Commercial Revolutions in Great Britain during the Nineteenth Century. London: George Routledge & Sons, Ltd., 1921.

Macara, Sir Charles W., Bt.—In Search of a Peaceful World. Manchester: Sherratt & Hughes, 1921. Presented by the Author.

Palmer, A. Risdon, B.Sc., B.A.—1. A Short Course in Commercial Arithmetic. 2. Transport and the Export Trade. 3. The Import Trade. 4. The Use of Graphs in Commerce and Industry. London: G. Bell & Sons, Ltd., 1921.

Paynter, J. E.—Practical Geometry for Builders and Architects. London: Chapman & Hall, Ltd., 1921.

Penzer, N. M., M.A., F.G.S.—The Tin Resources of the British Empire. London: William Rider & Son, Ltd., 1921.

Pickworth, Charles N.—The Slide Rule. 17th Edition. Manchester: Emmott & Co., Ltd., 1921.

Pigg, J. I.—The Photographic Instructor. Sixth Edition. London: Chapman & Hall, Ltd., 1921.

Searle, Alfred B.—The Clayworkers' Handbook. Third Edition. London: Charles Griffin & Co., Ltd., 1921.

Smith, Thomas Biddulph, F.C.S.—Coke-Oven and By-Product Works Chemistry. London: Charles Griffin & Co., Ltd., 1921.

Ward, J. S. M., B.A., F.S.S.—Cotton and Wool. London: William Rider & Son, Ltd., 1921.

Warner, Sir Frank, K.B.E.—The Silk Industry of the United Kingdom: its Origin and Development. Lodon: Drane, Ltd., 1921.

Waugh, Frank A.—Downing's Landscape Gardening. Tenth Edition. London: Chapman & Hall, Ltd., 1921.

Webb, M. de P., C.I.E., C.B.E.—Britain Victorious! A Plea for Sacrifice. Second Edition. London: P. S. King & Son, Ltd., 1920.

Webb, Sydney.—Grants in Aid. New Edition. London: Longmans, Green & Co., 1920.

White, Charles J., A.M.—The Elements of Theoretical and Descriptive Astronomy. Eighth Edition. New York: John Wiley & Sons. London: Chapman & Hall, Ltd., 1920.

Winbolt, S. E., M.A.—1. A Survey of English Grammar. 2. A Book of English Prose. London: Blackie & Son, Ltd., 1920 & 1921.

Woodhouse, Thomas, and Alexander Brand.—1. Textile Machine Drawing. Textile Mathematics. Part I. 2. London: Blackie & Son, Ltd., 1920 & 1921.

Woolsey, Theodore S.—Studies in French Forestry. New York: John Wiley & Sons. London: Chapman & Hall, Ltd., 1920.

Wright, C. R. Alder, D.Sc., F.R.S., and C. Ainsworth Mitchell, M.A., F.I.C.—Oils, Fats, Waxes and their Manufactured Products. Third Edition. London: Charles Griffin & Co., Ltd., 1921.

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FRIDAY, OCTOBER 28, 1921

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

OPENING OF THE 168th SESSION.

The Opening Meeting of the 168th Session will be held on Wednesday, the 2nd of November, when an Address (illustrated by Experiments) will be delivered by ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, on "Wireless Telegraphy." The Chair will be taken at eight o'clock.

ARRANGEMENTS FOR SESSION 1921-22.

Particulars of the arrangements for the forthcoming session, so far as they are at present completed, have been posted to all Fellows of the Society.

EXAMINATIONS, 1921.

The remarkable increase in the number of entries for the Society's Examinations which took place in 1920 has been more than maintained this year. This increase was steady from the beginning of the century to 1914. The five years of war naturally affected the figures adversely, but the total number of papers worked rose from 31,132 in 1919 to 49,390 in 1920—an increase of some 60 per cent.—and this figure has risen further this year to 51,267.

It is worth noting that in three important subjects the figures this year show slight decreases as compared with those of 1920. In English the entries were 2,930 in 1921, and 3,351 in 1920; in Typewriting they were 4,503 in 1921 and 4,634 in 1920; and in Shorthand they were 10,840 in 1921 and 12,411 in 1920. These three subjects were those prescribed for the *Daily Sketch* Prize Competition, which was held last year, and there can be no doubt that the offer of these handsome prizes attracted an unusually large number of candidates.

It was suggested in last year's report, that in addition to the *Daily Sketch* Competition, the principal causes of the sudden increase were twofold, one temporary, the other permanent. The first was the fact that a great many students who had been called up to serve, were anxious to complete their courses of study which had been interrupted by the war; the second was the increasing recognition of the value of education and of the necessity for obtaining tangible evidence, such as certificates, diplomas, etc., of its possession. The first temporary cause is happily becoming less and less effective, and we may safely assume that the second is becoming correspondingly more and more powerful. In addition to the general cause, too, there is little doubt that the Society's Certificates, as they are more widely known, are more highly appreciated. A very considerable number of important business firms now encourage their employés to enter for these Examinations, and some grade their staffs according to the certificates which they obtain.

The Examinations were held this year at two periods, March and May, as has been the custom since 1915. In March the number of entries was 16,658, and in May 38,538. The papers worked were divided between the two Examinations as follows:—

	March.	May.	Total.
Advanced Stage	1841	6284	8125
Intermediate Stage	4617	14,476	19,093
Elementary Stage	9226	14,823	24,049

In addition to the 51,267 papers worked in the written Examinations, 914 Candidates presented themselves for the *viva voce* Examinations in Modern Languages.

The subjects of Examination this year were:—

Arithmetic.
English.
Book-keeping.
Economic Geography.
Shorthand.
Typewriting.
Economic History.
Economic Theory.
Précis-writing.
Commercial Correspondence and Business Knowledge.
Commercial Law.
Company Law.
Accounting.
Banking.
Theory and Practice of Commerce.
Railway Law and Practice.
Shipping Law and Practice.
French.
German.
Italian.
Spanish.
Russian.
Dutch.
Portuguese.
Swedish.

Arithmetic.—The total number of papers worked was 4,387, as compared with 3,988 in 1920 and 2,814 in 1919. The number of papers worked in Stage III. was 126: 25 candidates obtained first-class certificates, 49 obtained second-class certificates, and 52 failed. The result is a great improvement as compared with the figures for last year, particularly in the percentage of first-class certificates. In Stage II., the number of papers worked was 1,032: 181 candidates obtained first-class certificates, 523 obtained second-class certificates, and 328 failed. The percentage of failures here is about normal. In Stage I. the number of papers worked was 3,229: 2,086 candidates passed, and 1,143 failed. The Examiner reports that the results in Mental Arithmetic were very fair, but there is still considerable room for improvement in the Tots and in the Decimalisation of money. In Part II. there is a general improvement in the style and neatness of the answers, though at certain centres the style is still very bad. Teachers can hardly impress too strongly upon students the importance of these points, not only in Arithmetic, but in every subject of examination.

English.—The total number of entries in all three Stages was 2,930. This shows a satisfactory increase over the 1919 figure of 1,169, although it is a falling off from the total of 3,351 in 1920, when, as has already been mentioned, English was one of the subjects prescribed for the *Daily Sketch* Prize Competition. Seeing that a sound knowledge of English is the bedrock on which all our education—commerical or otherwse—ought to be built, one would like to see a very marked increase in the entries here. In Stage III. there were 106 candidates: 13 obtained first-class certificates, 52 obtained second-class certificates, and 41 failed. The work was slightly better than that submitted last year but not so good as could be wished. The Examiner draws attention to the fact that the answers to the questions on literature smacked, as a rule, too much of the text book and too little of first-hand acquaintance with the works mentioned. Many are of opinion that at this Advanced Stage it is undesirable to set prescribed books, as candidates ought by this time be able to select their own reading, but experience unfortunately shows that only the best can be trusted to do this, while the average student contents himself "cramming tips" and "snippets." For this reason the Council have decided to prescribe books in Stage III. as they have already done in Stages I. and II., in the hope of compelling students to read and study at least three good books. For 1921 the books set are Shakespeare's "King Richard II," Carlyle's "Past and Present," and "Poems of To-day" (published for the English Association by Sidgwick and Jackson, 1916).

In Stage II, there were 941 candidates (as against 1,237 last year) and of these 105 obtained first-class certificates, 548 obtained second-class certificates, and 288 failed. The average standard of work is distinctly lower than that of 1920. The Examiner comments on a fault in composition which is much more common than it should be and that is the habit of writing in an exclamatory style, bristling with sentences without finite verbs. It cannot be too strongly impressed upon students that the first object in English Composition is to express their meaning as briefly, simply and naturally as possible.

In Stage I. there were 1,883 candidates (as against 2,026 last year) and of these 1,277 passed and 606 failed. It is satisfactory to note that the Examiner reports some slight general improvement in English Composition: "there is less of the hopelessly bad English which has been so common

in this Stage, and fewer candidates fail through excessive shortness in their answers." As on previous occasions, a number fail through the deductions made for illegible handwriting. Many candidates do not appear to realise how they jeopardise their chances of success by writing which is difficult or impossible to read, and teachers would be well advised to impress upon their pupils the practical advantages of a neat and clear hand.

Book-keeping continues to be far the most popular subject. This year the total number of papers worked in all stages was 17,300, as compared with 15,241 in 1920 and 9,151 in 1919. The next most popular subject is Shorthand, in which 10,840 papers were worked. In Stage III. there were 3,396 candidates, of whom 418 obtained first-class, and 1,696 obtained second-class certificates, while 1,282 failed. The percentage of failures, 37.35 is about normal. In Stage II., there were 6,596 candidates, of whom 635 obtained first-class certificates, 3,965 obtained second-class certificates, and 1,996, or 30.26 per cent., failed. The Examiner reports that taken as a whole the quality of the work falls below the usual standard, many candidates having little idea as to how they should deal with such points as depreciation, unexpired insurances, etc. In Stage I, there were 7,308 candidates of whom 4,663 passed and 2,645, or 36.19 per cent. failed. These results are slightly better than those of last year.

Economic Geography.—In Stage III. the answers included some better work than has been submitted for years. Some of it was of a very high quality. There were 30 candidates: 8 obtained first-class certificates, 13 obtained second-class certificates, and 9 failed. In Stage II., there were 63 candidates, of whom 8 obtained first-class certificates, 20 obtained second-class certificates, and 35 failed. In Stage I., of 137 candidates, 78 passed and 59 failed. In both Stages II. and I., the Examiner finds that failures went in groups, which seems to suggest faulty teaching. A remark in his report might well be taken to heart by teachers of this and every other subject: "Candidates must be taught *to read the questions*, and answer the questions as set instead of answering different, but somewhat similar, questions."

Shorthand.—In Stage III., there were 870 candidates, of whom 80 obtained certificates at 140 words per minute, 278 obtained certificates at 120 words per minute and 512 failed. In Stage II., there were 5,449 candidates, of whom 1,206 obtained certificates at 100 words per minute, 1,847 obtained certificates at 80 words per minute, and 2,396 failed. In Stage I. there were 4,521 candidates, of whom 2,955 gained certificates at 60 words per minute, and 1,566 failed. Last year the entries in this Stage numbered 5,269. It is probable that the decrease of 748 is mainly due to the fact that the speed test in this Stage was raised from 50 to 60 words a minute. Next year, in Stage I., as in Stages II. and III., there will be two speeds, viz., 50 and 60 words a minute. The Examiner, as usual, gives a list of the commonest mistakes in the transcripts. In most cases it is fairly easy to see how they have arisen; but it is difficult to understand how a candidate in Stage III. could transcribe the phrase, "It will, I think, not be long delayed," as "do well on the slab, and particularly well in geology."

Typewriting.—The total number of entries was 4,503. In Stage III. there were 312 candidates, of whom 69 obtained first-class certificates, 162 obtained second-class certificates, and 81 failed. The Examiner reports that the standard attained was much below that of the last two or three years. A large number of the papers which were handed in before the expiration of the time allowed, bore traces of haste and slovenliness. Candidates, especially in the Advanced Stage, should realise that accuracy and neatness are essential in typewriting, and that the saving of a few minutes is no compensation for the sacrifice of these qualities. In Stage II. the work submitted was more satisfactory. Of 1,572 candidates, 349 obtained first-class certificates, 987 obtained second-class certificates, and 236 failed. In Stage I. the work, with a few exceptions, was very creditable. There were 2,619 candidates, of whom 1,990 passed and 629 failed.

Economic History.—The Examiner reports that in Stage III. (where of 24 candidates 16 obtained first-class certificates, 7 obtained second-class certificates, and only 1 failed), the amount of first-rate work was striking. "There was abundant evidence of diligent study, resulting in full precise knowledge." Unfortunately, in Stage II., on the other hand, the results generally were disappointing. Of 63 candidates, 8 obtained first-

class certificates, 20 obtained second-class certificates, and 35 failed.

Economic Theory.—There were altogether 264 entries in this subject, as compared with 183 last year. 114 candidates entered for Stage III., and of these, 25 obtained first-class certificates, 58 obtained second-class certificates, and 31 failed. In Stage II., of 150 candidates, 19 obtained first-class certificates, 101 obtained second-class certificates, and 30 failed. The general level of the work done appears to have been fairly satisfactory.

Précis-Writing.—The total number of entries for this subject was 110; there were 47 candidates in Stage III., of whom 6 obtained first-class certificates, 31 obtained second-class certificates, and 10 failed; and in Stage II. there were 63 candidates, of whom 6 obtained first-class certificates, 46 obtained second-class certificates, and 11 failed. Some changes were introduced into the syllabus last year with a view to making the subject more useful as an exercise in English, and the examiner reports a substantial improvement in the standard of the candidates' work, but the number of entries shows a slight falling off as compared with the figures for 1920.

Commercial Correspondence and Business Knowledge.—The entries here, 3,219, show a slight increase of 72 over the figure for 1920. There were 75 candidates in Stage III.: only 2 of these obtained first-class certificates, 47 obtained second-class certificates, and 26 failed. The number of first-class papers is very disappointing. In Stage II., of 827 candidates, 41 obtained first-class certificates, 521 obtained second-class certificates, and 265 failed. In Stage I. there were 2,317 candidates, of whom 1,498 passed and 819 failed.

Commercial Law.—The number of entries in this subject was 545, an increase of 116 over the total for last year. 88 obtained first-class certificates, 347 obtained second-class certificates, and 110 failed. The papers showed a good general knowledge of the principles of Commercial Law, and on the whole reached a satisfactory standard. The Examiner, in his report, draws attention to some of the more usual mistakes and causes of failure. Among these, unfortunately, are illegible writing, which, as he remarks, cannot be read, and want of attention to instructions. Candidates at this stage should realise that when two alternative questions are set it is waste of time to answer both of them.

Company Law.—Here, too, as in the last subject, the work on the whole was satisfactory. The number of entries rose from 278 in 1920 to 433, an increase of 155. 95 candidates obtained first-class certificates, 273 obtained second-class certificates, while only 65 failed. Two answers quoted by the Examiner in his report should hardly have been written by candidates for a Stage III. examination: (1) "Generally speaking the legal position of a secretary is practically nil;" and (2) "A disinterested quorum is when the required number are present, but who take no interest in the meeting, but desire to converse with one another."

Accounting.—804 candidates entered for this subject, as compared with 582 in 1920. Of these 98 obtained first-class certificates, 424 obtained second-class certificates, and 282, or 35 per cent., failed. Although a little below the standard of last year's work, the work was, on the whole, creditable.

Banking.—The number of candidates in this subject shows a slight falling off from last year, the figure being 59, as compared with 75. It is, however, satisfactory to note that the Examiner reports an improvement in the quality of the work submitted. 9 candidates obtained first-class certificates, 26 obtained second-class certificates, and 24 failed.

Theory and Practice of Commerce.—In all there were 555 candidates in this subject: 173 entered in Stage III., of whom 17 obtained first-class certificates, 111 obtained second-class certificates, and 45 failed; while 382 entered in Stage II., of whom 25 obtained first-class certificates, 268 obtained second-class certificates, and 89 failed. The Examiner reports that the general standard of the candidates' work tends to improve, but papers of outstanding merit are uncommon.

Railway Law and Practice.—This, and the following subject, were set for the first time in 1921. An entry of 157 candidates for Railway Law and Practice may be considered a promising beginning. The twenty papers worked at the March Examination reached a very satisfactory standard, only four of the candidates failing. Those who sat at the May Examination, however, did not do nearly so well, and a large proportion of them were inadequately prepared.

In all, 20 Candidates obtained first-class certificates, 91 obtained second-class certificates, and 46 failed.

Shipping Law and Practice.—Only 23 Candidates entered for this subject. With the very large number of shipping firms in the country, it is to be hoped that the number of entries will increase substantially as the examination becomes more widely known. 5 candidates obtained first-class certificates, 12 obtained second-class certificates, and 6 failed. The Examiner complains that as a rule the papers showed a lack of accuracy and clearness of expression, and he points out that "nothing will compensate for the lack of a precise and accurate knowledge of the law and the legal terms."

MODERN LANGUAGES.

Last year the Council decided that in and after 1921 oral examinations should be compulsory for all candidates entering for French, German, Spanish, and Italian in Stage III. (Advanced). It is obvious that the value of a certificate in these subjects is enormously increased if it testifies that the holder possesses an adequate colloquial knowledge of the language in which he has been examined. The Council were also of opinion that in taking this step, they would be encouraging schools to adopt the best methods of teaching modern languages. It was, of course, doubtful what effect the new regulation would have on the number of entries in these subjects. Although there have been slight decreases in French and Italian, they are not as large as might have been expected, while in German and Spanish the numbers increased. The following Table shows the figures for 1920 and 1921, in the four languages to which the new regulation applies :—

	1920	1921
French	740	625
German..	62	71
Italian	22	17
Spanish	83	91

Oral Examinations were held at 76 centres, and were conducted by 52 Examiners. Every effort was made to enable Candidates to be examined as near their homes as possible, and so avoid the trouble and expense of long railway journeys. In all 914 Candidates presented themselves for the Oral Examinations (as compared with 431 in 1920), and of these, 245 passed with distinction, 515 passed, and 154 failed.

French.—In Stage III., 625 Candidates presented themselves, of whom 115 obtained first-class certificates, 381 obtained second-class certificates, and 129 failed. In addition to those entering for the whole of the Examination, 98 entered for the Oral Examination alone: there were thus 723 Oral Candidates, of whom 183 passed with distinction, 405 passed, and 135 failed. The Examiner reports that the work as a whole leaves a favourable impression, for, though distinguished work was not very common, there was a large average of good passes. In Stage II., of 1,535 Candidates, 113 obtained first-class certificates, 1,079 obtained second-class certificates, and 343 failed. In Stage I., there were 1,537 Candidates, of whom 1,121 passed and 416 failed. In all three stages there were 3,697 entries, as against 3,058 in 1920.

German.—The entries in German, 332, show an increase of 80 over the figure for last year, which was 252; but this subject has still a long way to go before it recovers its pre-war popularity, when the entries were 826 (in 1914). The Oral Examination does not seem to have had any discouraging effect, for in Stage III. the entries were 71, an increase of 9 over last year's figure. Of these, 17 obtained first-class certificates, 33 obtained second-class certificates, and 21 failed. In Stage II. there were 125 candidates, of whom 35 obtained first-class certificates, 66 obtained second-class certificates, and 24 failed. The Examiner reports that the translations into German and the essays were better than they have been for some years past, but the answers to the grammatical questions were weaker than they should be. In Stage I., of 136 Candidates, 66 passed and 70 failed. The work of those who sat at the March Examination was, on the whole, very creditable, but, according to the Examiner, the majority of the papers worked in May were "thoroughly bad. . . . . The translation into German and the free composition showed that very few of the candidates took the trouble to think of what they were trying to say."

Italian.—There were 79 entries in Italian, as compared with 77 last year. In Stage III. of 17 Candidates, 5 obtained first-class certificates, 9 obtained second-class certificates, and 3 failed. In Stage II., of 32 Candidates, 5 obtained first-class certificates,

26 obtained second-class certificates, and only one failed. In Stage I., 26 passed and 4 failed. The Examiner reports very favourably of the work done in Stages I. and II., but the answers of those who failed in Stage III. were very poor indeed.

Spanish.—The number of entries in this subject continues to grow in a satisfactory manner. In 1919 the total was 386 (up till then the highest figure); in 1920 it had risen to 551, and this year there has been a further increase to 633. In Stage III. there were 90 Candidates; only 4 obtained first-class certificates, 68 obtained second-class certificates, and 19 failed. Grammatical errors are still far more frequent than they should be at this stage, and the Examiner attributes the small number of first-class papers to insufficient practice in free composition. The same cause seems to account largely for the same feature in Stage II., where out of 225 Candidates, only 16 obtained first-class certificates, 161 obtained second-class certificates, and 48 failed. In Stage I., where out of 317 Candidates 224 passed and 93 failed, the Examiner reports an improvement in the general standard of work as compared with that of last year.

Russian.—The entries in Russian unfortunately show no evidence that this language is recovering the popularity which it suddenly obtained in 1917, when there were 266 Candidates. This year the total, 55, is just one short of the figure for 1920. In Stage III. there were 22 Candidates: 5 obtained first-class certificates, 13 obtained second-class certificates, and 4 failed. The standard of work in this Stage was considerably higher than in 1920: the passages set for translation were generally well rendered, and the answers to the grammatical questions showed that most of the Candidates had an accurate practical knowledge of the niceties of Russian idiom and construction. In Stage II. there were 18 Candidates: 8 obtained first-class certificates, 10 obtained second-class certificates, and there were no failures. The Examiner reports: "The work generally, was very good, and there were several papers of great merit. Some Candidates delighted the Examiner by giving an excellent free rendering of the English passage in colloquial Russian." The standard of the work in Stage I. (where there were 15 Candidates, of whom 10 passed and 5 failed) was only fair, and some of the papers compel the Examiner to repeat his appeal that no Students should attempt this Examination without acquiring a thorough knowledge of the elements of Russian grammar.

Dutch.—Eight Candidates entered in Stage II., of whom one obtained a first-class certificate, one a second-class certificate, and six failed.

Portuguese.—Examinations were held in this subject in Stages III. and II. In Stage III. there were 5 Candidates, of whom 1 obtained a first-class certificate, 2 obtained second-class certificates, and 2 failed. In Stage II. of 8 Candidates, 2 obtained first-class certificates, 6 obtained second-class certificates, and none failed.

Swedish.—There were 7 Candidates in Stage II., of whom 4 obtained second-class certificates and 3 failed.

Commercial Knowledge Certificates.

It is interesting to note that there has been a satisfactory increase in the number of Candidates entered from Higher Elementary Schools, and also the new Central Day Schools set up under various Education Authorities. Most of these Candidates take a group of subjects qualifying for the Certificate in Elementary Commercial Knowledge. To gain this special Certificate, Candidates must pass in Arithmetic, Book-keeping, English and one other subject within three consecutive years, but it is satisfactory to find that many pupils from the Day Schools mentioned above, pass in the necessary subjects in one year. In view of the fact that a fairly high standard is maintained in the Elementary Stage (it is by no means a first year's examination) the results at Day Schools under the local Education Authorities mentioned, set forth in the tables on page 819 give evidence of really excellent preparation.

Principal Alterations in the Syllabus.

Attention has already been drawn to the fact that three prescribed books will henceforth be set for candidates in English, Stage III., and the reasons for the change have been explained above. It has also been mentioned that in Shorthand, Stage I., there will be two rates of speed (viz., 50 and 60 words a minute), as in Stages II. and III.

The following new subjects have been added to the Syllabus:—

MARCH EXAMINATIONS.

	Elementary Stage, 1921.		
	Number of Candidates.	Number of Papers Worked.	Number of Certificates Awarded.
Chatham, Junior Commercial School	41	103	79
Leyton, Capworth Street Central School	87	156	127
West Ham, Central Secondary School	29	85	82
L.C.C. Brownhill Road Central School	16	54	50
L.C.C., Mina Road Central School	28	49	45

MAY EXAMINATIONS.

	Elementary Stage, 1921.		
	Number of Candidates.	Number of Papers Worked.	Number of Certificates Awarded.
Ashford (Middlesex), County School	11	75	68
East Ham, Higher Elementary School	207	578	438
Halifax, Municipal Technical College	147	252	212
Kingston-on-Thames, Day Commercial School	60	98	85
Lerwick Central Public School	10	33	32
Preston, Harris Institute	30	155	107
Tranent, Higher Grade Public School	42	108	81
West Ham, Water Lane Higher Elementary School	20	116	93
Wood Green, Central School	53	109	93
York, Day School of Commerce	26	50	42

In Stage III., Insurance Law and Practice, and Railway Economics.

In Stage II., History of Inland Transport in Great Britain.

In addition to the above, Papers in Commercial Law and Company Law will be set in future in both Stages II. and III. instead of in Stage III. only, and papers in Theory and Practice of Commerce will be set in all three Stages instead of in Stages III. and II. only.

It may be mentioned that in instituting an examination in Insurance Law and Practice, the Council have no intention of establishing a certificate which should compete in any way with the diplomas already issued by professional bodies. Their idea is rather to meet the needs of certain students pursuing a general course of study in commercial subjects who, it is believed, will find this examination useful in testing their knowledge of an important branch of their education.

The Council have also decided to establish two new Group Certificates for—

(*a*) Shorthand Typists,
(*b*) Shipping Clerks.

For (*a*) Candidates must pass in the following subjects within three consecutive years :—

Shorthand, 140 or 120 words per minute

Typewriting, Stage III.,

English, Stage II.,

and either a modern language (Stage II.) or Commercial Correspondence and Business Knowledge (Stage II.). The speed of the certificate gained in Shorthand and the class of certificate gained in the other subjects will be endorsed on the Group Certificate.

For (*b*) Candidates must pass in the

TABLE A.—DETAILS OF THE 1921 EXAMINATIONS.

SUBJECTS.	STAGE III.—ADVANCED.				STAGE II.—INTERMEDIATE.				STAGE I.—ELEMENTARY.			Total number of Papers worked in all Stages.	
	Papers worked.	1st-class Certificates.	2nd-class Certificates.	Not passed.	Papers worked.	1st-class Certificates.	2nd-class Certificates.	Not passed.	Papers worked.	Passed	Not passed.	1921	1920
Arithmetic	126	25	49	52	1,032	181	523	328	3,229	2,086	1,143	4,387	3,988
English	106	33	52	41	941	105	548	288	1,883	1,277	606	2,930	3,351
Book-keeping	3,396	418	1,696	1,282	6,596	635	3,965	1,996	7,308	4,663	2,645	17,300	15,241
Economic Geography... ...	30	8	13	9	60	4	34	22	137	78	59	227	275
Shorthand	870	80	278	512	5,449	1,206	1,847	2,396	4,521	2,955	1,566	10,840	12,411
Typewriting	312	69	162	81	1,572	346	990	236	2,619	1,990	629	4,503	4,634
Economic History	24	16	7	1	63	8	20	35	—	—	—	87	92
Economic Theory	114	25	58	31	150	19	101	30	—	—	—	264	183
Précis-writing	47	6	31	10	63	6	46	11	—	—	—	110	122
Commercial Correspondence & Business Knowledge ...	75	2	47	26	827	41	521	265	2,317	1,498	819	3,219	3,147
Commercial Law	545	88	347	110	—	—	—	—	—	—	—	545	429
Company Law...	433	95	273	65	—	—	—	—	—	—	—	433	278
Accounting	804	98	424	282	—	—	—	—	—	—	—	804	582
Banking	59	9	26	24	—	—	—	—	—	—	—	59	75
Theory and Practice of Commerce	173	17	111	45	382	25	268	89	—	—	—	555	566
Railway Law and Practice ...	157	20	91	46	—	—	—	—	—	—	—	157	—
Shipping Law and Practice ...	23	5	12	6	—	—	—	—	—	—	—	23	—
French	625	115	381	129	1,535	113	1,079	343	1,537	1,121	416	3,697	3,058
German	71	17	33	21	125	35	66	24	136	66	70	332	252
Italian	17	5	9	3	32	5	26	1	30	26	4	79	77
Spanish	91	4	68	19	225	16	161	48	317	224	93	633	551
Russian	22	5	13	4	18	8	10	—	15	10	5	55	56
Danish and Norwegian ...	—	—	—	—	—	—	—	—	—	—	—	—	3
Dutch	—	—	—	—	8	1	1	6	—	—	—	8	7
Portuguese	5	1	2	2	8	2	6	—	—	—	—	13	7
Swedish...	—	—	—	—	7	—	4	3	—	—	—	7	5
Totals, 1921	8,125	1,141	4,183	2,801	19,093	2,756	10,216	6,121	24,049	15,994	8,055	51,267	—
" 1920	7,062	1,098	3,430	2,534	18,696	2,964	9,499	6,233	23,632	15,890	7,742	—	49,390

following subjects, within three consecutive years :—

(1) Shipping Law and Practice,

(2) Theory and Practice of Commerce (Stage III.),

(3) Economic Geography (Stage III.).

They may also take a Modern Language, Stage II.; this, however, is optional. The class of certificate gained in each subject will be endorsed on the Group Certificate.

The Court of the Clothworkers' Company have again generously renewed their grant of £40, to be expended in providing medals in all the subjects of examination where the work of candidates attains a sufficiently high standard. There is no doubt that these medals are highly valued by those who win them, and they have done much to maintain or raise the level of excellence in the papers worked.

The Examination Syllabus for 1922* has been issued. In it will be found the fullest possible information about the examinations, a syllabus of each stage of each subject, and a list of centres. The papers set in March and May, 1921, have been reprinted in six pamphlets. Each pamphlet contains, in addition to the papers of each stage, the syllabuses of the subjects in the pamphlet and the Examiners' reports on the papers worked in 1920. The attention of both teachers and students may be drawn once more not only to the syllabuses but also to the remarks of the various examiners on the results of last year. It will be found that these contain many valuable and helpful suggestions, and the work of the candidates year after year shows that far too little attention is paid to them.

The regulations for the Oral Examinations in Modern Languages are also given at full length in the syllabus.

* The price of the Syllabus for 1922 is 4*d*., post free. Copies can be obtained on application to the Examinations Officer, Royal Society of Arts, Adelphi, London, W.C. (2). The price of the pamplets containing the 1921 papers is 4*d*. each, post free. Particulars of these may be obtained as above.

TABLE B.—ORAL EXAMINATIONS HELD DURING 1921.

Subject.	No. of Examina-Centres.	No. of Examiners	No. of Candidates examined.	Passed with Distinction.	Passed.	Failed.
French	52	34	723	183	405	135
German	9	7	73	22	42	9
Spanish	11	8	93	25	58	10
Italian	3	2	19	12	7	—
Russian	1	1	6	3	3	—
	76	52	914	245	515	154

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RECENT APPLICATIONS OF THE SPECTROSCOPE AND THE SPECTROPHOTOMETER TO SCIENCE AND INDUSTRY.

By SAMUEL JUDD LEWIS, D.Sc., F.I.C., PH.C.

LECTURE III.—*Delivered April 25th*, 1921.

The latter part of the last lecture was devoted to the development of the Sector Spectrophotometers and it now remains to show in what manner they have been applied in the investigation of absorption spectra to the purposes of science and technology. The work of Hartley, Baly and others, which has thrown so much light on the constitution of organic compounds, is well known, as also that of Dobbie on the absorption spectra of the alkaloids; and the Journals abound in papers relative to the value of the method as a branch of physical chemistry; but, as explained by the introduction of sector spectrophotometers being so recent, most of the work in the ultra-violet region has been done by the older methods and these have not lent themselves to the purposes of the industrial chemist.

But the new instruments have made the ultra-violet absorption spectrum accessible

to all. It would be interesting to consider some of the more remarkable results attained, but it will serve the purpose of these lectures just to review a few examples which illustrate the very varied applications of the new apparatus to those subjects which have hitherto been neglected for want of convenient means.

It was my privilege to give the first British order for one of the Hilger Sector Spectrophotometers in 1913 before one of them had even been made, save only a workshop model. But what to do with it, I did not then know. However, before the instrument was delivered, the Beit Research Fund Committee of the British Homeopathic Association had responded to a suggestion that an investigation of the ultra-violet absorption spectra of Blood Serum might lead to interesting results. Thereupon they made grants in aid of the work, and further, it is largely due to that body that the Sector Spectrophotometer has been developed as it has.

A study of the absorption spectra of serum would not attract many of our systematic chemists, because serum is not a definite chemical compound of known constitution. However, the work has proved most fruitful, and is at the moment far more promising than could have reasonably been anticipated. A brief review of some of the work will be interesting.

The method of experiment is very simple. Five or six drops of blood are collected in a capillary tube, the corpuscles centrifugalised out, and the clear serum transferred to a cell. After the thickness of the layer, which is less than the fifth of a millimeter, or about 1/150 in., has been measured with an accuracy of one thousandth of a millimeter or the one twenty-five-thousandth part of an inch, the cell is placed in the Sector Spectrophotometer for its absorption spectrum to be studied. It should be noted that the serum is not treated in any way; it is not even diluted.

Such procedure would be practically, if not quite, impossible by the older method of Hartley, where the spectra were graded by varying the thickness of the layer. The quantity of blood required would be inconveniently large for the patient, and the large amount of handling of the cell would not be agreeable to the operator when pathological sera were in hand; further, the details of the results would not be sufficiently precise to be of any value for say clinical diagnosis.

Our first slide is an early one, showing the whole absorption band of a sample of serum on one plate. How it differs from more recent work will be appreciated by the series of spectra of another specimen, which are so numerous as to necessitate their distribution over three plates. One member of a set of three such plates is shown in Figure 6 (p. 803). The greater wealth of detail in the latter is of the utmost value in the application of the work to either science or clinical practice. If the absorption spectrum of serum varies at all with the pathological or other abnormal condition of the subject, the variation will certainly be small. One cannot look for severe distortion of the curve, for that would imply great modification of the proteins or other constituents of the serum and point to such very serious changes in the condition of the patient as are rarely, if ever, found in practice.

The absorption curve of normal serum is shown in Figure 13. Its characters have

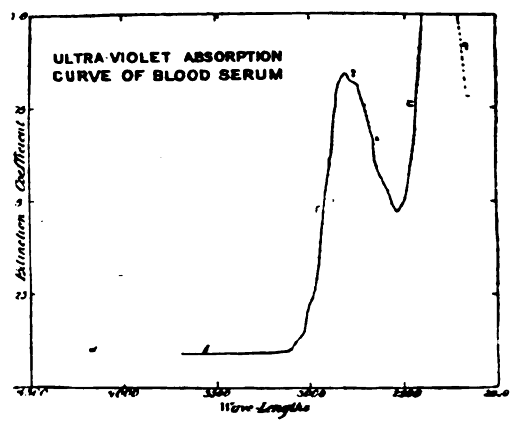


FIG. 13

been fully discussed in a paper read before the Royal Society. (Proc. Royal Soc. B, 89, 1916, 327-335).

Since then the curve for normal serum has been very thoroughly investigated with a view to discovering the origin of the various characters of the curve. The albumin, pseudo-globulin and eu-globulin have been separated by chemical means and the individual proteins have been submitted to spectrophotometric measurements. The general result has been to show that the two globulins give very similar bands, but they are not quite alike, either in human or in horse serum. The albumin gives a

small band, with features which distinguish it clearly from the globulins.

The non-proteins of serum fail to modify appreciably the form of the absorption band due to the mixed proteins, and in view of the toxins and antitoxins related to disease associating with and modifying the proteins, it is not too much to anticipate some important clinical application of the spectroscopic method, whether for diagnosis or otherwise.

An abstract from the paper cited will illustrate this and indicate the possible value of the method to the study of disease.

"Some thirty specimens of blood have "been examined in connection with typhoid, "and the results are very encouraging. "The chief effect observed is that the point "of least absorption value between the "sections ε and ζ is shifted from 2540 to "2510, and at the same time raised slightly.

"This result has been arrived at in two "ways: First, a series of three specimens of "blood was taken from each of six soldiers; "(*a*) normal, immediately before inocula-"tion against typhoid; (*b*) 41 hours after "the first inoculation; (*c*) 20 hours after "the second inoculation, 11 days later. "The serum was separated and examined "in the usual way, and the above named "effect was observed in five out of six cases. "Blood from 11 cases of actual or suspected "typhoid was examined. In six instances "the above effect obtained fully; in two, "the displacement was to 2530 only; "in two, the position was unchanged. In "one described as clinically a typical case "of typhoid and as having failed three "times to give the Widal reaction, the "movement was in the opposite direction "to 2550.

"In most cases there is a reduction in "the amplitude of the curve between the "depression at 2540 and the head at 2800.

"Another modification observable in the "inoculation cases is that the step-like "prominence at the bottom of section γ is "somewhat greater after inoculation than "before, in five cases out of six. The "sixth case is also the exception with "regard to the displacement modification "mentioned above."

Two papers on "Ultraspectroscopic Studies in Blood Serum," one by T. Tadokoro and the other by T. Tadokoro and Y. Nakayama, appeared in America in the Journal of Infectious Diseases, for January, 1920. The inquiry was on somewhat similar lines, but unfortunately the work was not quantitative, and so it is not strictly comparable with that now described.

A few films of Cellulose derivatives have been examined, and it has been found that the character of the absorption curve is in some measure an expression of the chemical constitution of the cellulose compound composing the film. The curves for the acetic and nitric esters exhibit a low absorption in the near ultra-violet and a high absorption beyond 2800; a slight "hump" in the curve occurs about 2770, but the investigation has not gone far enough to say whether it is an undeveloped band or not. The nitrate is the denser.

Three specimens of viscose were rather less transparent than cellulose acetate at wave-lengths between 4000 and 2700. The curve does not become steep until beyond 2300.

The relation of Rubber to the absorption of light, especially of ultra-violet light, has for some time been a subject of inquiry, especially with reference to the deterioration of rubber in sunlight. Most experiments have had for their object the incorporation of dyes or other agents in the rubber for the purpose of absorbing the ultra-violet rays at the surface and so avoiding their penetration into the body of the material.

But until a few months ago no systematic quantitative examination of rubber with a view to ascertaining its absorbing powers appears to have been made. A little preliminary work showed that pure caoutchouc is remarkably transparent to light of wave-length 3000 and even of 2700; beyond that the absorption curve is steep.

Thus a contribution has been made to our knowledge of the technology of rubber, and a fresh step has been taken towards the study of the chemical constitution of caoutchouc.

(See "Preliminary Note on the Absorption of Light by Caoutchouc," Jour. Soc. Chem. Ind. 1921, 40, T. 18; by S. Judd Lewis, D.Sc., F.I.C., and B. D. Porritt, M.Sc., F.I.C.)

Glass is daily subjected to examination for its light transmitting and light absorbing properties according to the purpose in view, and not a little of the work, is more or less spectrophotometric in its aim, even when accurate measurements are not made.

There are three new glasses all of which have been of great use in the conduct of the war, their utility depending entirely upon

their respective spectroscopic properties.

The first is the spectacle glass, a truly scientific product resulting from the researches of the late Sir William Crookes. This glass allows very little ultra-voilet light to pass, and so avoids the irritation and fatigue to the eye which accompanies the use of the more transparent spectacles.

The second is ultra-violet glass which has the opposite properties. It is a dark red glass having nickel in its composition, which transmits ultra-violet light only, all the visible light being absorbed except a very little in the far red. This is very useful for making experiments in fluorescence where rays of very short wave-length are not required.

The third is didymium glass which exhibits the narrow twin bands in the yellow region of the spectrum characteristic of this "element."

The spectra of the first two of these and of ordinary glass are shown in Figure 14.

with increase of the atomic weight of the halogen. So recently as 1912 Crymble had concluded by the older method that these salts are entirely diactinic (Jour. Chem. Soc. 1912, T, 101-266); hence it is fair to assume that but for the new photometers, the recognition of the bands would have been long delayed.

But this, which is very significant as a result of the new photometric procedure, is not the most impressive part of the work. They also confirmed that it is possible to throw light on the state of chemical equilibrium in a solution. And in particular they found that the oscillation frequency of the bands of all the chlorides was 2730, of the bromides 3570, and of the iodides 2883. The band for chlorine gas is at 3060 and substances containing a halogen atom which is not ionised exert only slight general absorption. Hence, the bands observed with the salines are apparently associated with the halogen, whilst in an ionised condition. However, this was shown to be not the whole explanation, for the absorption band of a saturated solution of potassium iodide was much more persistent than that of a quarter-saturated solution. The results lead to the assumption that the bands are due to the vibrations set up in the halogen ions by the influence of the metallic ions.

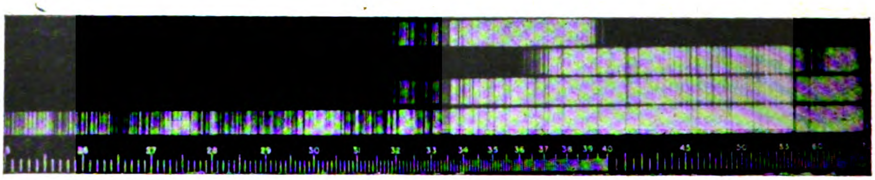


FIG. 14.—Absorption spectra of glasses. 70 is in the far red, 40 is at the end of the violet; all beyond is ultra-violet. The spectra indicate the amount and nature of the light passing (1) through Chance's ultra-violet glass showing no visible light, (2) through Chance's "Crookes A" glass, which transmits very little in the ultra-violet, (3) through spectacle crown glass, which allows a considerable amount of ultra-violet light to pass, (4) through quartz which transmits rays of all wave-lengths.

Quite other fields of inquiry have been opened up by quantitative absorption spectroscopy in the ultra-violet region by means of the new Sector Spectrophotometers.

A good example is an investigation of "the quantitative absorption of light by simple Inorganic Substances" by Branningan and Macbeth (Jour. Chem. Soc. T, 1916, 109, 1277-1286). These workers have brought modern methods to operate in an old field where much work has been done, but much of it is now obsolete or not comparable with present knowledge in other fields. The first efforts have been directed to a study of the chlorides, bromides and iodides of the alkali metals, and they have been fruitful in discovering that all these salts exhibit slight but well-defined selective absorption in the ultra-violet region, and that the frequency of the bands decreases

The extensive reference to this inquiry is not made because of the undoubted importance of the results, but rather as an indication of the possibilities of the new facilities. With the latest (fourth) photometer described in the last lecture, still other vistas will open up, especially the opportunity of making rapid observations of the progress of a chemical reaction. It is probable that it will be possible to photograph a series of twenty or even thirty or more absorption spectra in one minute,

and thus provide a new means of studying the progress of a chemical reaction or controlling a process.

One more instance of the quantitative value of the absorption spectrum must be mentioned, it refers to the direct investigation of gases. It is the determination of the small quantities of Nitrogen Peroxide in the gases evolved during the decomposition of gun cotton, elaborated by Robertson and Napper. (J. Chem. Soc. 1907, T, 91, 761-786).

The apparatus used was a Hilger No. 1 table spectroscope, with a single dense flint glass prism, provided with a camera for photographing the spectrum. A Welsbach incandescent mantle was used as the source of light, and the vessel for containing the gas under investigation was a straight glass tube, 40 cm. long, with the ends closed by glass plates.

The characteristic absorption spectrum of nitrogen peroxide consists of a large number of fine dark lines extending throughout the visible spectrum and a general absorption which is strongest in the violet (the gas being red in colour), and diminishes gradually as it approaches the red end.

A series of standard photographs was made using known mixtures of nitrogen peroxide and carbon dioxide, containing 0.05 to 1 per cent. of the former, and then experiments were made with the gases

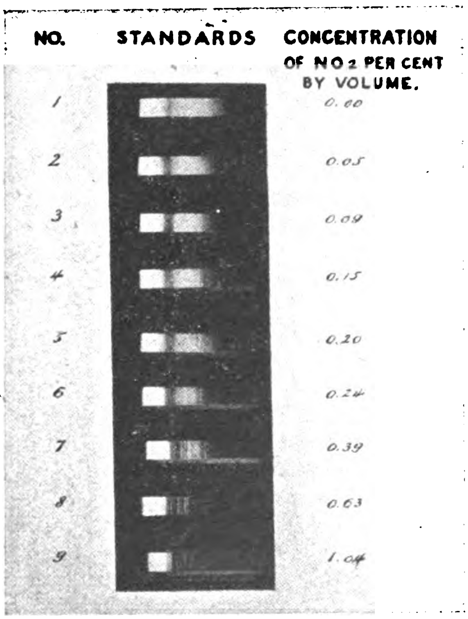


FIG. 15

resulting from the mixture of nitric oxide with air in various proportions. By comparing the photographs from these with the standards, results closely agreeing with those to be expected were obtained, and the method was then applied to the gases resulting from the decomposition of gun-cotton. The importance of the work lies in the fact that changes in the composition of the products can be studied through the course of the experiment using quantities of gas that are too small for ordinary chemical analysis, and that the resulting facility has shed new light on the nature of the decomposition of gun cotton.

The method has been found trustworthy, and has been successfully used in the investigation of the gaseous products of the decomposition of explosives in Government works at Waltham Abbey and elsewhere.

There can be little doubt, however, that if the observation tube were fitted with quartz ends and placed in the sector spectrophotometer, results of even wider interest might be attained.

Subjects which have engaged much attention for a number of years are Fluorescence and Phosphorescence. These appear to differ little from each other except that fluorescence exists only so long as the exciting rays continue to act, while phosphorescence persists after the stimulus is removed. Extensive researches have been conducted, but we shall refer to only a few which are embraced by the title of these lectures.

One is a series of observations on "The Fluorescence of Cellulose and its Derivatives," undertaken at the suggestion of our Chairman, Mr. C. F. Cross, F.R.S., in consequence of the following statement of Hartley in 1893. "There is one substance "which I have not mentioned which is "remarkably fluorescent, namely, unsized "paper. The whole of the ultra-violet "spectrum as far as wave-length 2000 is "rendered visible when allowed to fall on "a sheet of white blotting-paper; but "this fluorescence is without distinct colour. "The eye must be rendered sensitive by "being in the dark for some minutes, and "no stray rays of light must illuminate "the paper; but so distinctly are the "lines in the spectrum of cadmium made "visible that they may be well focussed on "such a screen. This can only be the "case if the paper is fluorescent to all the

"rays, and that these are lowered in "refrangibility.

"Obviously rays of such short wave-"length as are invisible under ordinary "circumstances because they are absorbed "by the aqueous humour of the eye, could "not be seen by reflection, and, if they could, "a sheet of glass would render them visible "when viewed at a proper angle.

"It must therefore, be the case that the "paper is fluorescent." (J. Chem. Soc., 1893, T. 245-256).

No-one seems to have followed up Hartley's observation until Mr. Cross drew my attention to it. It was then found that after rendering the eye sensitive by darkness, similar, but even still more striking observations could be made by means of the quartz spectrograph. By placing a piece of suitable paper over the aperture in the camera, and looking at the paper from the outside, the paper is seen to have been penetrated by nearly the whole of the ultra-violet spectrum. Each of the strong lines is seen as a fluorescent glow. There is one important difference between this work and Hartley's. Hartley viewed the effect by apparent reflection, the new method was to observe the effect by apparent "transmission." This seeming transparency of paper will be dealt with later when describing the photographic method.

Several papers and fabrics were examined when it was discovered that some were much better than others, that acetylated specimens were more powerfully fluorescent than normal ones, and that nitration depressed the effect.

Visual methods soon gave place to photographic observations, and in due course the Council of the Society of Dyers and Colourists in collaboration with the Department of Scientific and Industrial Research gave the necessary financial aid. Full accounts of the work are published in the Journal of the Society. (August, 1918).

The photographic method was an outcome of the facilities ready to hand at the moment, but they served the purpose remarkably well. The specimen is attached to the glass side of a photographic plate which is then placed in the camera of the spectrograph with the paper towards the light source and the photographic film away from it. It follows that the ultra-violet rays fall on the paper, and then in a degraded form pass through the glass before reaching the sensitive film. If no paper is used or if a delicate wire gauze or other inactive medium takes its place, no photograph whatever is produced. Passage of the ultra-violet rays is cut off by the glass. It follows that the paper possesses the power of increasing the wave-length of the rays until they are visible and so have the power to pass through glass; that is, the paper is fluorescent.

The effect at the wave-lengths named is that produced by the degradation of the light of that particular wave-length. The wave-length of the light to which it has been degraded has not been ascertained; but since this light is visible, it must have a wave-length exceeding 4000.

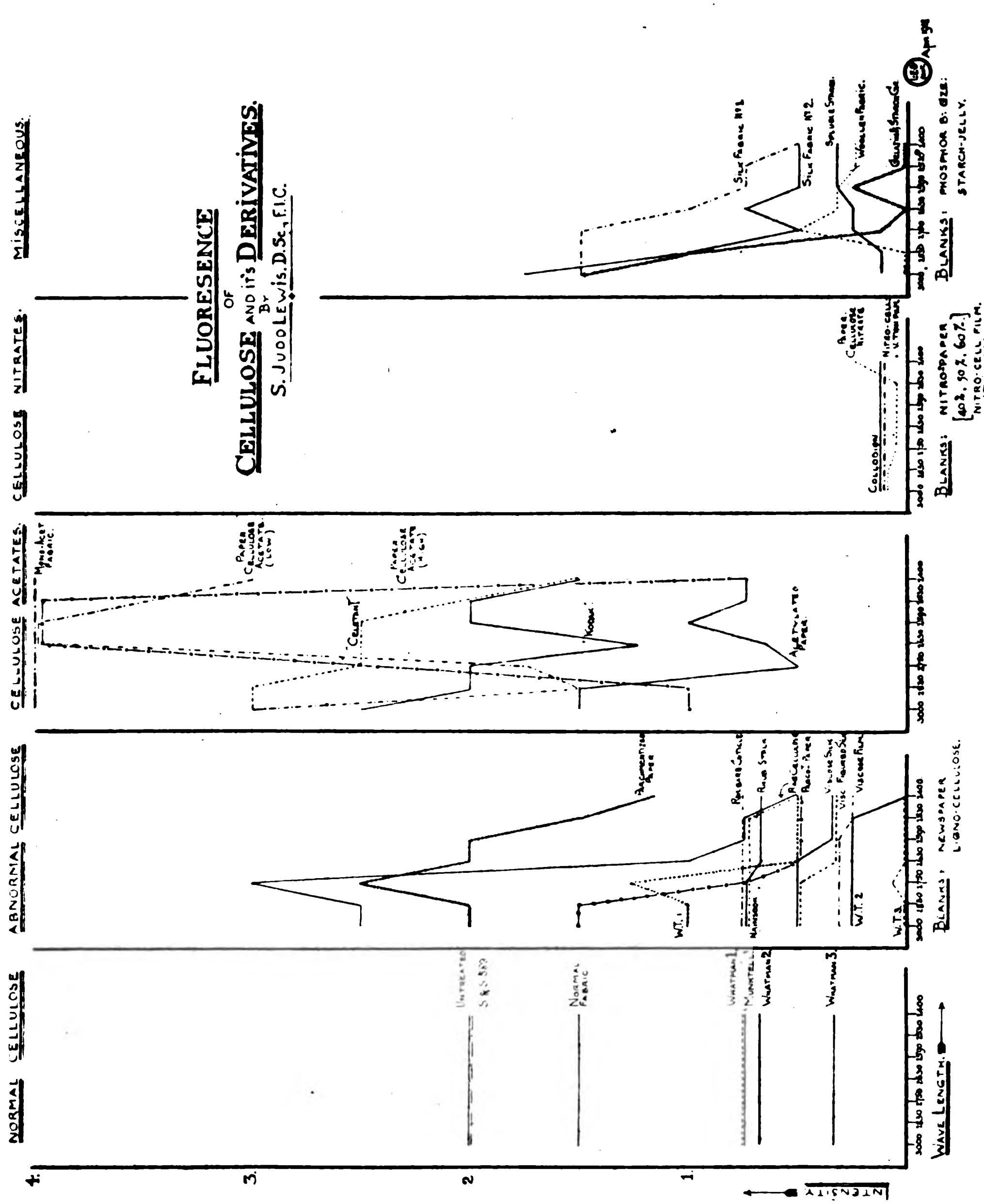
In the curves the intensities are plotted as ordinates, and the wave-lengths as abscissæ.

The curves of Fig. 16 display the chief results of the inquiry both in quantity and in character. For convenience the specimens are classified according to their chemical constitution, and a separate set of curves is drawn for each class, from the general characteristics of which it is evident that the chemical constitution finds definite expression in the power and distribution of the fluorescent properties.

Although all these results harmonise so well it was felt that there might be more than one factor of difference between any two specimens, so Mr. Cross very kindly prepared at my request, a series of specimens from the same filter-paper, upon each of which the usual observations were made, under the most uniform conditions. It follows that each derivative differed from the original paper by one factor only, namely, its chemical difference. The photographs reproduced in Figure 17 exemplify the change in fluorescenct power brought about by chemical treatment. The upper, weaker, effect is that due to the original filter paper; the lower, stronger, fluorescence is that of the same paper after acetylating. The same filter paper after nitrating was entirely without action.

This work has proceeded much further in the meantime. Methods have been improved, and most of the difficulties described have been avoided or overcome, but above all, means have been devised for making truly quantitative determination of the fluorescent power of the specimen at any wave-length, on spectrophotometric principles. The work is well advanced, and it is hoped shortly to publish a report on it.*

*An "Interim Report" has since been published. Jour. Soc. Dyers and Colourists, August, 1921.



FLUORESENCE OF CELLULOSE AND IT'S DERIVATIVES.
By S. JUDD LEWIS, D.Sc., F.I.C.
NORMAL CELLULOSE
ABNORMAL CELLULOSE
CELLULOSE ACETATES
CELLULOSE NITRATES
MISCELLANEOUS
WAVE LENGTH
INTENSITY

FIG. 16

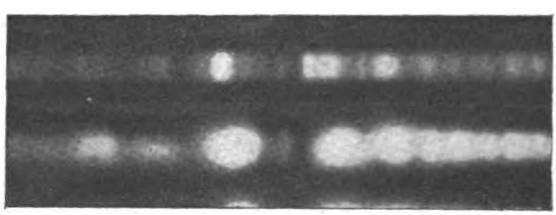


FIG. 17.

And now these lectures draw to a close. They have in some measure justified their title of "Recent applications of the Spectroscope and the Spectrophotometer to Science and Industry," for very little has been described which was common knowledge ten years ago. But, even so, some of the most important discoveries of the period in the realm of Spectroscopy have received no more than mention.

The marvellous attainments achieved in helping to elucidate the structure of the atom, the architecture of the crystal and the evolution of a star have been left for others to deal with. Nothing useful could have been crowded into the present course. Each of them would demand a ten-fold course for its adequate treatment.

An effort has been made to display some of the more immediate applications of spectroscopy as an aid to the study of the various natural sciences, to medicine and to industry. Very wide fields have been surveyed. But others equally extensive and equally fruitful have been passed by. The ultra-red region which has commanded so much attention in the Carnegie Institute in America, Professor Baly's theories correlating the ultra-red with the regions of shorter wave-length, as well as many new researches on the expression of chemical constitution in the spectrum, as exemplified by the work of Crymble and his colleagues, remain untouched.

With such a vast amount of invaluable knowledge and experience, one is led to inquire how it is that an adequate spectroscopic outfit is not found in every well-furnished laboratory.

Undoubtedly the first reason is a fundamental one; proper equipment and experienced teaching in this subject are all too uncommon in our Universities and schools. In those cases where this criticism does not apply, the professor devotes himself almost entirely to his own special theme, with the result that very little general training is available for the student. Hence, very few spectroscopists skilled in general work are to be found, and so the analyst and the medical school devise other means for solving their difficulties.

Secondly, there has been nothing very startling to awaken public interest. Everyone appreciates the unique wonder and the value of the X-rays revealing the position of a fracture in a bone, but few amongst us realise the possibilities economically of the spectral ray.

The present is the threshold of the future, and we cannot be far from that day when in science and in industry alike our knowledge will be enriched by regular and wide-spread appeal to critical spectroscopic investigation becoming the advantage of the many, and no longer the restricted privilege of the few.

[NOTE.—The author's thanks are due to Messrs. Adam Hilger, Ltd., for kindly exhibiting a large quartz spectrograph, sector spectrophotometers and accessories, and for providing practical demonstrations.]

OBITUARY.

SIR EDWARD CHANING WILLS, BT.—Sir Edward Chaning Wills died at his residence, Harcombe, Chudleigh, Devon, on the 14th inst., after an operation. Born in 1861, he was educated at Emmanuel College, Cambridge, and became a director of the Imperial Tobacco Company, Limited, in which the Bristol firm of Wills was absorbed. He succeeded his father, Sir Edward Payson Wills, K.C.B., in the baronetcy in 1910. He was a generous supporter of the Royal Devon and Exeter Hospital, the Royal Albert Memorial, Exeter University College, and other public institutions. He acted as first President of the Devonshire Regiment Volunteer Training Corps in 1915, in which year he was High Sheriff of the County. He was elected a Fellow of the Royal Society of Arts in 1905.

CHARLES DAY.—The death took place recently of Mr. Charles Day, who had been a Fellow of the Society since 1871. He was born in 1846, and educated at St. Paul's Cathedral Choir School, among his fellow pupils being Sir John Stainer and Mr. Goss. He was the Chairman of Day's Library, which was originally situated in Berkeley Square. In 1810 it was purchased by Mr. Rice, and subsequently removed by him to 123, Mount Street. After several changes it passed into the hands of John and Charles Day, successively, and under the superintendence of the latter it was removed to its present quarters, 96, Mount Street, in 1890. In 1904 it was formed into a private company.

PETER LE NEVE FOSTER.—Mr. Peter Le Neve Foster died at Nice on October 13th. Born in Hertfordshire in 1839, he was the eldest son of the late Peter Le Neve Foster, who was Secretary of the Royal Society of Arts from 1853 to 1879. He was educated at the Collège Commercial at Boulogne, and was later apprenticed to Messrs Scott Russell, of Milwall, during the construction of the

steamship *Great Eastern*. For many years he was employed in Italy, Transylvania and the United States on irrigation schemes. He was the engineer for the important irrigation of the Lomellina, a large tract of land on the right bank of the Ticino, and he superintended the completion of the Quintino Sella, the principal branch of the Canal Cavour. The distinction of Chevalier of the Order of the Crown of Italy was conferred on him by the late King Victor Emmanuel. Later he was in the employment of the Thames Conservancy and was responsible for the lock on the Thames at Richmond. He was a frequent contributor to the Society's *Journal*.

NOTES ON BOOKS.

FIFTY YEARS OF ELECTRICITY: THE MEMOIRS OF AN ELECTRICAL ENGINEER. By J. A. Fleming, M.A., D.Sc., F.R.S. London: The Wireless Press, Ltd. 30*s*. net.

The fifty years' development described in this narrative covers the period 1870 to 1920. Before that time electrical engineering was practically limited to land and submarine telegraphy: now it would be difficult to enumerate all the spheres in which electricity serves us. It runs our trains and trams; lightens our darkness; provides power for our factories; works our telegraphs and telephones, electric bells and railway signals; cooks our dinners—in short, enters into our daily lives in a hundred-and-one ways. And who could be better qualified to write the history of this development than Professor Fleming? For over forty years he has been intimately associated with the scientific progress of electrical industry and has himself been one of the most fertile inventors of electrical apparatus. In 1879 he was scientific adviser to the Edison Telephone Company when it was formed to begin telephone exchange working in London; in 1882 he held a similar position with the Edison and Edison and Swan Companies, then engaged in introducing electric lighting by incandescent lamps, and later on he gave much scientific assistance to the Marconi Company in developing the system of wireless telegraphy over long distances. In addition to this, for 36 years he has been Professor of Electrical Engineering at University College, London. There is, however, little need to explain at greater length Professor Fleming's qualifications for this task to Fellows of the Royal Society of Arts. He has lectured here brilliantly on many occasions, and only this year the Council awarded him the Society's Albert Medal—the highest honour in their power to confer—"in recognition of his many valuable contributions to electrical science and its applications, and specially of his original invention of the Thermionic Valve, now so largely employed in wireless telegraphy and for other purposes."

Professor Fleming has divided his book into seven chapters, which deal respectively with telegraphs and telephones; dynamos, alternators, transformers and motors; electric lamps and electric lighting; electric heating, cooking and furnaces; electric supply stations, storage batteries, railways and the transmission of power; electric theory and measurements; and wireless telegraphy and telephony. The story of the development of each of these branches during the last fifty years is told in language so simple that it may be understood by anyone with an elementary knowledge of electricity; and mingled with the more technical descriptions are vivid sketches of the great scientists to whom this development is due. The author has known them all personally, and with many of them he has worked in close association. He went up to Cambridge in 1877 with the chief object of working under James Clerk Maxwell, and since that time he has numbered among his friends Kelvin, Rayleigh, Stokes, Joule, Edison, Swan, Lodge, Marconi—all the giants of the electrical world. The volume forms, then, what it sets out to be—a comprehensive and readable account of the chief triumphs of applied electricity during the last half-century: it is profusely illustrated, and forms a fine memorial of a long and distinguished career.

THE SWISS INDUSTRIAL JEWEL INDUSTRY.

The history of the manufacture of industrial jewels in Switzerland is closely related to that of the watch industry. Watches with jewelled pivots were made in Geneva more than a century ago, but until comparatively recently the making of the jewels was simply an item in the process of watchmaking, itself a typical family industry and carried on with primitive equipment, though with superlative skill.

While watch jewels are still perhaps the most important class, industrial jewels, as they are manufactured to-day, fall into four general classes: (1) Watch and chronometer jewels, (2) scientific and precision instrument jewels, (3) phonograph jewels, (4) wire and filament drawing jewels.

The raw materials for the above-named classes of industrial jewels are, in order of their degree or hardness: Diamonds, corundums (known as rubies, sapphires, and amethysts, depending upon their colour), garnets, and agates. Synthetic corundums, which are somewhat cheaper than the natural stones and of equal or even superior hardness, are also used. The manufacture on a commercial scale of these synthetic stones has been successfully carried on for the last 15 years.

The raw diamonds used for this industry originate in Brazil, Africa, and India, but the supply is actually obtained from London. Raw

corundums (rubies, sapphires, and amethysts) are obtained chiefly from Siam, Ceylon, and India, although sapphires are procured from America also. Raw garnets come from Czecho-Slovakia, South Africa, and India, and agates from America and Germany. Synthetic corundums are produced in France, Germany, and Switzerland, one plant alone in the latter country turning out about 100,000 carats daily.

The raw materials used for watch and chronometer jewels are chiefly corundums (natural and synthetic), and, for the cheaper grades of this class, garnets. For instrument jewels agates, in addition to corundums and garnets, are used. Agates and corundums are used for phonograph jewels, while for wire-drawing jewels diamonds are used exclusively. Diamonds are also used for sawing and cutting all other materials and diamond dust or powder is used to polish jewels of all materials.

According to a report by the U.S. Consul at Berne, the manufacturing process consists of a number of distinct operations. The first operation, now done entirely by machine, is the sawing or the grinding of the raw material into plates or "bolts." For this purpose thin copper discs with diamond-studded edges are used. The plates or bolts are then cut to the approximate size of the finished jewels. These "rough jewels" are fixed upon small individual discs with gum lac and then they are turned. If a watch jewel is to be produced, it is also pierced.

If the jewel is intended for an instrument, such as an electrometer, for instance, it is not pierced, but merely hollowed out by a further turning operation and finished in the form known as the "cup jewel." After being turned the jewels are polished and angled. The last-named operations are usually done by hand and the quality of the finished jewel depends largely upon the degree of skill possessed by the operator.

Some of the operations above referred to are so highly specialised that at the present time one factory usually performs only one or two operations. Sawing the raw material into plates or bolts, cutting these to the approximate size, piercing or hollowing the rough jewel, and turning to finished size are special operations done by some factories exclusively. There are few factories in Switzerland equipped to perform the entire operations necessary to produce all the classes of jewels mentioned above, although one enterprise claims to produce everything from the synthetic corundum to the finest quality of finished jewel of each class.

The machinery used in the manufacture of industrial jewels is highly specialised, designed in most instances by the manufacturers themselves, and built by local machinists and makers of fine mechanical apparatus. There are no standard tools, each manufacturer using his own preferred types.

The demand for industrial jewels is reported generally to be definitely increasing. Although the industry was adversely affected by the war, owing to the scarcity of raw materials and certain import and export restrictions, these conditions no longer obtain, and while the demand is still below the volume of production, the industry is decidedly prosperous.

The largest demand for industrial jewels at the present time still comes from the watch industry, principally domestic, and secondarily American. Next in importance is the electrical instrument industry, the rapid development of which in Switzerland and abroad involves a constantly growing demand for jewels to be used for pivots and counterpivots. There is said to be an increasing demand also from manufacturers of other types of precision instruments and meters. The phonograph industry, with its rapidly growing use of permanent reproduction points, and the plants manufacturing wire for such apparatus as electric filaments, are other important sources of demand for special types of industrial jewels.

By far the biggest foreign customer of the Swiss industry is the United States. In 1919 Switzerland exported industrial jewels amounting to 11,875,000 francs, of which total the United States took 7,105,000 francs. France in the same year took 2,040,000 francs and the balance of 2,730,000 francs went principally to England and Germany.

MINERAL WATER INDUSTRY OF CZECHO-SLOVAKIA.

Before the war the exportation of mineral waters was one of the important industries of Austria-Hungary, and a very large percentage of the exported water came from springs now included in the Czecho-Slovak Republic. Since the war, and particularly last year, writes the U.S. Assistant Trade Commissioner at Prague, the mineral water trade has suffered. There seem to be three principal causes for the stagnation: (1) Greatly increased freight tariffs, making it impossible to ship water to foreign countries with profit; (2) a disposition on the part of certain other countries to place prohibitive tariffs on the import of mineral waters; and (3) a falling off in the domestic demand.

In order to discuss these problems and to take steps for meeting them, the Ministry of Commerce has held a general conference of those interested in the industry. The conference was attended by a number of Government officials and by representatives of the mineral-water bottling establishments in Carlsbad (Karlovy Vary), Marienbad (Marianske Lazne), Podebrad, and several other localities.

The report of the inquiry committee shows that in former years from 75 to 80 per cent. of the so-called Austro-Hungarian mineral-water exports came from springs now in Czecho-

Slovakia. The war marked the beginning of a very considerable decline in the earnings of the spring owners. The reason was that the Czecho-Slovak Republic is so rich in mineral springs that the bottling trade cannot flourish except by exporting, and there were obstacles in the way of exporting. In 1919 the domestic consumption was only 50 per cent. of what it had been before the war and the exports amounted to only 20 per cent. In 1920 the situation was still worse. The home demand had fallen to 40 per cent. of the pre-war figures, and the exports were only 10 to 15 per cent. as large.

Under such conditions the smaller springs were forced out of business altogether, and even the large establishments, such as those at Carlsbad and Marienbad, found themselves in danger of failure.

As a result of the conference just held, resolutions were prepared petitioning the Government to favour the mineral-water trade by a thorough revision of freight rates, special rates for the return of empty bottles, export premiums, arrangements with foreign countries for the importation of Czecho-Slovak mineral waters under more favourable tariff arrangements, etc.

SOAP INDUSTRY IN CHINA.

If all the 400,000,000 of China's population were users of soap, the demand would be enormous, but the use of washing soap in China is confined largely to the Chinese living at or near the treaty ports and large trade centres. The Chinese housewife in the interior still adheres to the old-time custom of washing her clothes at the village pond or creek where they receive a hard beating over some stone at the edge of the water.

In the place of the laundry soap used by westerners the Chinese housewife uses a native substitute known as soap beans. This vegetable soap is of two kinds, one variety being the product of the tree *Gymnocladus Chinensis*, and the other of the tree *Sapindus-Hukorossi*. This former tree produces a large, thick pod, about 2½ to 5 inches in length by 2 inches in width. These pods contain seeds about double the size of a broad bean. Between the inner membrane and the outer skin of the pod is a thick layer of brown tallow. It is this tallow which gives the pod its value as a washing material, producing a good lather in either hot or cold water. Sometimes these pods are cut up very fine, ground to a paste, and mixed with either sandal-wood, cloves, musk, or camphor and honey. The resulting mixture, which is dark brown in colour, and has the consistency of soft soap, is used largely by the women as a cosmetic. Native barbers also use it as a salve on the heads of their customers.

The other soap tree mentioned bears a fruit about the size of a marble, consisting of a hard black seed, enclosed in a light-brown fleshy integument, the inner lining of which is a clear glistening membrane, containing tallow fat. This tallow is used for washing white cloths, it being cleaner than the product of the first-mentioned tree.

Imported foreign washing soaps formerly had a wide distribution in the treaty ports and outlying districts, but recently foreign varieties of soap have met with considerable competition on the part of native factories. According to a report by the U.S.A. Vice-Consul at Hankow, there are four large native soap factories in that city, and while it is difficult to state the yearly output of these mills, as no statistics are published, yet it is safe to estimate the local output in the neighbourhood of 60,000 cases a year. The largest of these native factories has little or no modern machinery.

The method used is comparatively simple. After the soap stock is properly prepared in large iron cauldrons, it is poured into huge wooden moulds about 4 feet square. When the mould has set, the wooden frame is removed. In this shape, the huge block is allowed to dry for five or six days, after which it is cut into bars by means of wires strung across a wooden frame. A modern steel hand press stamps the trade mark on the cake, after which it is wrapped by hand and packed in the case ready for shipment. Local Chinese soaps contain no resin.

The local factories push the sale of their wares by advancing soap to the shops and collecting the money only when the goods have been sold. In this way the stores are well supplied with native chops or brands, and for this reason the native dealer prefers to deal with the factories direct. On the other hand, the foreign firms selling soap to the Chinese demand cash in advance. It is this method on the part of the Chinese soap manufacturers that has eliminated a great deal of the foreign competition.

GENERAL NOTES

THE DE MORGAN WORKS AT THE VICTORIA AND ALBERT MUSEUM.—Among the admirable series of catalogues published by the Victoria and Albert Museum, special attention may be drawn to the pamphlet describing the works of William De Morgan. The first pages contain a short biographical note of De Morgan; this is followed by a technical note on the manufacture of De Morgan tiles and pottery. It is the work of Mr. Halsey Ricardo, who was for many years associated with De Morgan as a partner, and gives an extremely clear and interesting account of the methods pursued in the factory. Next, we have a descriptive catalogue of the collection of De Morgan works in the Museum, and finally come sixteen plates giving excellent representations of his lustre and "Persian" work.

PRODUCTION OF SILVER.—A new volume on Silver Ores, in the Series of Monographs on the Mineral Resources of the Empire produced under the direction of the Mineral Resources Committee of the Imperial Institute, has just been published by Mr. John Murray (price 6s. net). It is written by Mr. H. B. Cronshaw, B.A., Ph.D., A.R.S.M., lately Professor of Geology, University College, Galway. Silver, alloyed with copper, is mainly used in the manufacture of coin, plate and jewellery. The world's production of silver from 1910 to 1913, inclusive, averaged upwards of 224 million fine ounces per annum, but from 1914 to 1917, inclusive, the average annual output fell to 173½ million ounces. During 1918 and 1919, the annual production recovered to upwards of 191 million ounces. The first chapter of the monograph deals with the world's production, values, properties and uses of silver, and briefly describes silver ores and their metallurgical treatment. In the second chapter the silver-bearing deposits of the British Empire are described, especially those of British Columbia, of the Cobalt and Gowganda districts of Ontario, and of the Yukon, Canada, and those containing silver-lead-zinc at Broken Hill, New South Wales, and silver lead in various districts in Tasmania. The third and last chapter contains descriptions of the silver-bearing deposits of foreign countries, especially those of the United States, Peru, Mexico, Chile, Bolivia, Colombia, Spain, Portugal, Germany, Austria, Hungary and Asia Minor.

LAWES AGRICULTURAL TRUST LIBRARY.—The Library of the Lawes Agricultural Trust now contains most of the books and journals which the agricultural expert needs to consult for purposes of preparing reports, etc. The Director has forwarded to the Royal Society of Arts a list of the journals and periodicals contained in the library, some of which are not easily accessible elsewhere in the country, and he will be glad to give facilities to any Fellow of the Royal Society of Arts who presents a card from the Secretary of the Society, to use the library without further formality. Journals and periodicals are not sent out, and they must be consulted at The Rothamsted Experimental Station, Harpenden.

HEMP PRODUCTION IN CANADA.—With reference to the General Note on this subject in the Journal of September 9th (page 724), Lieut.-Col. James A. Hesketh, C.M.G., D.S.O., sends the following extract from the *Winnipeg Tribune* of September 25th:—"Five hundred tons of hemp will be the yield of the first large hemp crop of Manitoba, grown under the direction of the Canada Fibre Company, Ltd., at Portage la Praire, according to the estimate of Col. William Grassie, president of the company. Cutting of the crop has commenced, it was announced. In addition to the 200 acres, cultivated by William Richardson, under the direction of the fibre company, farmers of the Swan River district have 400 acres under cultivation, it was learned. The hemp will be disposed of to two European manufacturers, Col. Grassie said, until factories can be established in Canada."

MEETINGS OF SOCIETIES FOR THE ENSUING WEEK.

MONDAY, OCTOBER 31 .. Mechanical Engineers Institution of (Yorkshire Branch). Albion Place, Leeds, 7.30 p.m. Mr. F. J. Bostock, "Gaseous Firing for Industrial Purposes."

Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W., 4 p.m. Dr. J. A. Voelcker, "How best to Utilize the Results of Agricultural Research in Practical Farming."

TUESDAY, NOVEMBER 1 .. Anglo-Batavian Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8.30 p.m.

Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, W., 4.30 p.m. Mr. R. Gardner, "The Via Valeria, Topography, Monuments and Relations to other Mountain Roads of Central Italy."

Civil Engineers, Institution of, Great George Street, S.W., 5.30 p.m.

WEDNESDAY, NOVEMBER 2 .. ROYAL SOCIETY OF ARTS. John Street, Adelphi, W.C., 8 p.m. Opening Meeting of the 168th Session. Address by Chairman of Council, Mr. Alan A. Campbell Swinton, on "Wireless Telegraphy."

British Academy, at the Royal Society, Burlington House, W., 5 p.m. Prof. A. F. Pollard, "The Elizabethans and the Empire."

Public Analysts, Society of, at the Chemical Society, Burlington House, W., 8 p.m. 1. Dr. C. B. Savory, "An Improved Specific Gravity Apparatus." 2. Drs. J. C. Drummond and A. F. Watson, "The Testing of Foodstuffs for Vitamins." 3. Mr. A. Lucas, "The Inks of Ancient and Modern Egypt."

Ingénieurs Civils de France, Society des, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 5.30 p.m. The Marquis de Chasseloup-Laubat, "The Efforts of France in the Reconstruction of the Devastated Regions."

University of London, South Kensington, S.W., 5 p.m. Sir Frederick Bridge, "Sir W. Leighton's Great Collection of Early 17th Century Motets by Eminent English Composers." (Lecture I.)

THURSDAY, NOVEMBER 3 .. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Sgdr. Ldr. R. M. Hill, "Manœuvres of Getting Off and Landing."

Linnean Society, Burlington House, W., 5 p.m.

Chemical Society, Burlington House, W., 8 p.m.

University of London, at the Imperial College of Science, South Kensington, S.W., 5.30 p.m. Mr. W. Bateson, "Recent Advances in Genetics." (Lecture I.) At the School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Mr. L. Binyon, "Japanese Art." (Lecture I.)

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Inaugural Address by the President, Mr. J. S. Highfield.

FRIDAY, NOVEMBER 4. .. Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. (Thomas Hawksley Lecture). Dr. H. S. Hele-Shaw, "Power Transmission by Oil."

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, November 9th, at 8 p.m. (Ordinary Meeting). D. R. WILSON, M.A., Secretary of the Industrial Fatigue Research Board, "The Work of the Industrial Fatigue Research Board and its Applications to Industry." WILLIAM GRAHAM, LL.B., M.P., Member of the Medical Research Council, will preside.

Further particulars of the Society's Meetings will be found at the end of this number.

FIRST ORDINARY MEETING.

The Opening Meeting of the 168th Session of the Society was held on Wednesday, November 2nd, when an experimental address on "Wireless Telegraphy" was delivered by Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council.

A full report of the meeting will be published in the *Journal* of November 18th.

THE RUSSIAN CONTRIBUTION, IN THE NINETEENTH CENTURY, TO THE METALLURGY OF STEEL.

By COLONEL NICHOLAS T. BELAIEW, C.B.

I. INTRODUCTION.

The progress of Russian Metallurgy in the 19th century is mainly due to two men—to the mining engineer, Major-General Paul Anossoff, and to Professor Demetrius Tschernoff.

The former rendered eminent services to metallurgy in introducing a highly perfected crucible process and in attacking the problem of the old Indian or Damascene steel in conjunction with the crucible steel process.

Tschernoff, the father of the metallography of iron, as he is called, became famous through his first paper on the critical points of steel, the principles exposed by him therein making possible the rational and effective heat treatment of steel.

The problems settled by them were immense, and the results of their labours far-reaching, but that is only one side of the question—the metallurgical side. What interests us so much in their work is not this side only, but the way in which they attained their achievements, how they settled the problems which seemed at the time of their researches to be impossible of solution, and what made possible for them things which seemed impossible for others. The importance of this side of the question lies in the fact that the success of both Anossoff and Tschernoff was due in no small degree to the highly efficient technical and scientific training which they received from the first steps in their careers.

It is quite true that "received" is not exactly what happened, because the highly efficient technical training to which I am referring was not received so much in some institutions or from some predecessors, but was the result of the surroundings and atmosphere which each of them created for himself and by himself. Nevertheless, the importance of the fact remains open to us, and we have to acknowledge that big results and great achievements are due not only to talent and energy, but also in no small degree to an efficient and well directed scientific and technical training.

Anossoff and Tschernoff, being both quite exceptional men, created these conditions for themselves, but, once having created them and recognised their importance, they did everything in their power to convey

the importance of their methods to posterity, and so Anossoff, and, more particularly, Professor Tschernoff, created a special Russian school of metallurgists, to whose credit are due many important and original scientific and practical works.

II. ANOSSOFF.

Major-General Paul Anossoff, Mining Engineer and Director of the Zlatooust Steel Works, in the Ural District, lived between 1797 and 1851. His main achievements were carried out during his directorship of the Zlatooust Works in the second quarter of the 19th century. The training of a mining engineer in the 19th century was kept at a very high standard, and Dr. Murchison paid a high tribute to many of them at that time. As to Anossoff we have the testimony of no less an authority than Humboldt himself, who paid a visit to the works and was presented with one of the Anossoff damascene blades.

The position of Zlatooust itself, on the Southern Ural slopes, between east and west, on the route over which trade between Ural on the one hand, and Persia and India on the other, was conducted from time immemorial, seemed predestined for the fusion of Western and Eastern ideas in the particular branch of industry for which Zlatooust and the Urals were renowned, viz., metallurgy. Eastern merchants, from Bokhara, from Persia and even from the Indian borderlands, called at appointed times at the Zlatooust works, to buy or to exchange some of their metallic wares for the native products. Quite naturally, the qualities and peculiarities of European and Eastern steels were noticed and compared, but no one before Anossoff conceived the idea of taking advantage of these facts in order to enrich the Western methods of steel making by the old Eastern practice. In his very instructive treatise on the Bulat or Damascene steel, he narrates how he was struck by the fact that, in determining the qualities of an Eastern blade the native was quite independent of any tests, and that it was sufficient for him to examine the watered surface with its motley design, what we now call the structure of the object; and what struck Anossoff most was the fact that the judgment of the Oriental was final and always correct. Having noticed this, he began to work in various directions. First, he resolved to settle the problem of the old Damascene steel, and spent ten years in various experiments, till he came to the conclusion that the old Indian or Damascene steel was a kind of high carbon crucible steel, mainly differing from the best English steel of his time in its pattern and, according to his firm belief, in its superior quality. Simultaneously, he did everything he could to bring to perfection the purity of his raw materials, the construction of his furnaces, and the quality of the crucible, each of these being in itself a formidable task in those days.

And now we come to the important point, how he set to work.

We have to remember that he worked, not in a laboratory, but in a big plant. He had no leisure for "scientific investigation." He did not even aim at that. What he aimed at was something else—the best possible kind of steel—and in order to attain his object, he proceeded in the most scientific way. He kept a diary of all his experiments, and in the days when chemistry was not what it is now, and when analysis was a rare luxury, he made himself analyses of the most difficult kind. Moreover, he examined most carefully every cake of steel just after his certification, and before and after every operation. Always under the influence of the Oriental point of view, he tried to find out to what was due the beautiful watering on the Damascene steel, very soon discovering a relation between this watering and the crystallisation of steel, and then, having detected the axes of these crystals on the surface of the steel cake, as taken out of the crucible, he identified these same crystalline axes with the motley of the blade.

You see the method he adopted. Being struck by some new fact, in his case the watering of the Damascene blade, he tried at once to find out the secret of this watering by way of experiments. He conducted these experiments until, after years of labour, he came to a successful issue, never faltering, never leaving the singleness of his purpose. His idea was correct, his methods were the right methods, and he was rewarded by a big success, and, as often happens, he found out even what he did not aim at, and, beginning with the study of Damascene blades, he became the real founder of microscopical metallography, and that, in 1841, many years before not only Tschernoff, Osmond and Martens, but even Sorby. He noticed that

the motley on the surface of the alloy was sometimes so indistinct that it was very difficult to discern it with the naked eye, so he applied the magnifying glass, and afterwards the microscope. In his diary he kept full records of all his microscopical investigations. The only thing which is missing are his original sketches, which, according to many witnesses, did exist. Unfortunately I have been quite unable to trace them, and, therefore, we have to be content with the mere fact that, in 1841, Anossoff, director of a big metallurgical plant, and conducting vast experiments with cast steel, examined each of his articles after a suitable treatment, with the naked eye, in order to see what we now call their macrostructure ; and, with an armed eye, their microstructure.

The importance of his work is very great, and that is the reward, not only of his talents and energy, but of the technical methods and of the technical training which he applied to all his studies.

III. Tschernoff.

The name of Professor Tschernoff*, the father of the metallography of iron, is known to every student of metallurgy throughout the world. His main work, to which his fame is due, is his treatise on the critical points of steel. This work was published fifty years ago, in 1868, and in it he describes the critical temperatures or critical points "a" and "b" which are of such vital importance to every steel maker. He defines the point "a" as a critical temperature. The quenching from a temperature below this point will result in no hardening. Therefore, in order to harden steel, it is necessary first to heat it above this critical point "a."

The point "b" is defined as such a critical temperature as implies the change of structure from a rough to a very fine one, or, as Tschernoff says, from crystalline to amorphous.

According to Tschernoff, the structure of steel above the point "b" is amorphous, and below it is crystalline. Therefore, it is possible to fix this amorphous structure at will, through a suitable kind of treatment.

You may wonder why such importance is attached to these temperatures. The reply is this: the scientific importance of them is proved by the fact that the two critical points of Tschernoff, "a" and "b," in the form adopted by Osmond, and expressed by him under the denominations "A1" and "A2," are the foundation of our present equilibrium diagram (of Roberts-Austen), of the iron carbon alloys, and, subsequently, of all other equilibrium diagrams.

According to Osmond, who is the final authority in these matters, all the subsequent development of physical chemistry lies in the critical points "a" and "b" of Professor Tschernoff. From the practical point of view their importance may be even greater, for no piece of steel can be suitably hardened without rigorously observing the conditions of heating and of quenching, as given by Professor Tschernoff, i.e., that the heating should be higher than point "a" and as close to point "b" as possible. The subsequent cooling, to a certain third critical point "d," must be conducted with a given speed.

That is as far as the hardening of steel is concerned, but modern practice shows that one of the most important technical operations is the so-called double annealing treatment which is based on the properties of the point "b" of Professor Tschernoff.

I do not wish to dwell too long on these technicalities, and I hope that my object will be sufficiently served if I mention that these highly important scientific and practical results were again obtained, not in a scientific laboratory, but in a big steel plant, by a young but well-trained engineer, who, without any devices or scientific instruments, simply by observing what occurred to every large forging after heating, and carefully recording these results in a note-book, made, amidst the noise of his steel plant, a discovery which was destined to form the nucleus of physical chemistry on the one hand, and of all modern steel industry on the other.

I suppose that these few lines devoted to the work of General Anossoff and Professor Tschernoff will be sufficient to prove the immense importance of the right combination of scientific and technical training for the young engineer.

Now-a-days, when, again and again, these problems of general and technical education are being brought before the public, it is interesting to recall what were the conditions under which the most illustrious men in every branch of science worked,

*Professor Tschernoff was elected an Honorary Corresponding Fellow of the Royal Society of Arts in 1900.

and how they achieved their brilliant results. As mentioned before, Anossoff, and more particularly Tschernoff, achieved what they did mainly because when working in a factory, they always stuck to the strict observance of scientific work, and, above all, of scientific thought and deductions. Should we not infer that truly scientific methods must be paramount both in general and in technical education? But that is not all. The splendid results of Tschernoff's work, bear testimony to the fact that the best scientific methods, even when used by such a brain as Tschernoff's, only bear their full crop of fruit when they are employed, let us say, in a factory. This does not mean that scientific researches have to be conducted in a factory. Tschernoff would have been the first to repudiate such an allegation. It simply means that, if you are working for any practical purpose, you have to work scientifically, and to apply the most suitable scientific methods.

Professor Tschernoff's work, as I have just remarked, is widely known throughout the whole world. In this country he has been elected Hon. Vice-President of such institutions as the Iron and Steel Institute, a reward of which he was especially proud. I think that, in bestowing this honour upon him, this country recognised not only all his achievements and the true importance of his work, but also the importance of his methods. In my opinion, the works of Anossoff and Tschernoff, the chief contribution of Russian science to metallurgy in the 19th century, are also the best example of what may be attained by a rational technical training and, subsequently, by the right kind of technical education.

NOTES ON WATER POWER DEVELOPMENT.*

The extent to which the water powers of the world have been investigated and developed during the past decade forms one of the striking engineering features of the period. Although falling or flowing water formed the earliest of the natural sources of energy to be utilised for industrial purposes, it is of interest to note that two-thirds of the water power at present in use has been developed within the last ten years.

The reasons for the revival of interest in this question are partly technical and partly economic.

The technical development of electric generation and transmission has made it economically possible to utilise powers remote from any industrial centre, while a rapid increase in the demand for energy for general industrial purposes and for the many electro-chemical, electro-physical, and electro-metallurgical processes which are now in general use, and whose field is rapidly growing, has provided a ready outlet for all such energy as could be cheaply developed.

The urgent demand for energy to supply the abnormal requirements of the war period, combined with the world shortage of fuel, was responsible for an unprecedented rate of development in most countries with available water power resources, and especially in those countries normally dependent on imported fuel.

Thus in France some 850,000 water horse-power has been put into commission since 1915, and the country now has 1,600,000 horse-power under control as compared with 750,000 before the war. In Switzerland some 600,000 horse-power has been developed since 1914, or is in course of construction, as compared with 880,000 horse-power before the war. In Spain, where the pre-war output was 150,000 horse-power, the present output is 620,000 horse-power, and about 260,000 horse-power is now in course of development, while the Spanish Ministerio de Fomento is considering the development of some 2,000,000 horse-power to be delivered into a network of transmission lines covering the industrial parts of the country.

In Italy, schemes totalling about 300,000 horse-power are under way, and it is estimated that the total output will shortly amount to 2,000,000 horse-power. The Government Hydrographical Department is now engaged in gauging and surveying the profiles of the principal rivers, and statistics of available reservoir sites, of lakes suitable for storage and of available horse-power are being compiled.

Japan, which only very recently began to investigate her water powers, has, since 1916, developed over 1,000,000 horse-power, or almost twenty per cent. of her available resources.

In Canada and the United States many large schemes have recently been brought into service, and some extremely large installations are now in course of construction or are projected. Thus the Queenston-Chippewa project on the Canadian side of the Niagara River is intended to develop some 500,000 horse-power, while a projected development of the St. Lawrence River will be capable of yielding 1,700,000 horse-power. In Canada the total development (2.3 million horse-power) in 1918 was almost three times as great as in 1910. In the United States of America the development has increased from something under two million horse-power in 1901, to 5.3 millions in 1908, and to nearly 10.0 millions in 1920.

Rapid as has been the development of water power in the United States in the past, it has

* Extracted from the Presidential Address of Professor A. H. Gibson, D.Sc., to the Engineering Section of the British Association at Edinburgh.

been retarded by the fact that the privilege of using the national forests or other public lands for water power development has only been granted by the issuing of permits which were not available for any definite period and which were revocable at the will of the Granting Authority. In the case of development on navigable streams, whether on public or private land, each scheme has required a special Act of Congress, and these Acts could be revoked by Congress at any time. Owing to the uncertainty of tenure there has naturally been some reluctance to invest capital in such undertakings.

By the recent Federal Water Power Act, signed in June, 1920, licences for such developments may now be issued under the jurisdiction of a new body, known as the Federal Power Commission, for a period not exceeding fifty years, at the end of which the licence may be renewed, or the Government may take over the enterprise upon compensation of the licensee. In the issuing of licences, preference is to be given to State and Municipal applications. The effect of this Act may be inferred from the fact that, within a month of its being signed, applications for licences to develop over 500,000 horse-power had been filed. The duty of collecting, recording, and publishing data regarding the utilisation of water resources, the water-power industry and its relation to other industries, and regarding the capacity, development costs, and relationship to possible markets, of power sites, has also been assigned to this Federal Power Commission.

World's Available Water Power.—During the past few years much attention has been paid to statistics of available and developed water powers. In the case of developed powers, these are usually stated in terms of the capacity of the installed machinery. This machinery is in general only used to its full capacity over a portion of each day, although in many such cases water is available for providing continuous power if desired.

Estimates of potential power are always to be accepted with considerable reserve. In order to make a reasonably accurate estimate, the run off from the catchment area and the variation in this run off from month to month and from year to year, must be known, and it is only in comparatively rare cases that this information is as yet available. Moreover, there is as yet no standard basis on which potential power is computed.

The power available from a given stream during the wet season is many times as great as during the dry season unless sufficient storage is available to equalise the flow throughout the year, and the cost of such storage would in general be prohibitive, even if it were physically possible to provide it.

The United States Geological Survey takes the maximum useful flow of a stream as being that which may be guaranteed during six months in each year. The minimum flow is taken as the average which can be guaranteed over the two driest consecutive seven-day periods in each year, along with the additional flow which may be obtained during this period by developing any available storage capacity in the upper waters of the stream. Estimates of potential power based on storage capacity are, however, subject to a wide margin of error owing to the limited data available, and in the following table the potential water power is estimated on the basis of the maximum flow as just defined, and in terms of continuous twenty-four-hour power.

(*Millions of Horse-Power.*)

——	Available	Developed.
Great Britain ...	0.9	0.2
Canada	23.0	3.28 *
Remainder of British Empire, including— Australia ... Africa (East) ... „ (South) ... „ (West) ... British Guiana India and Ceylon New Zealand ... Papua	30.0 to 50.0	0.7
Austria	6.5	0.57
Brazil	26.0	0.32
Dutch East Indies	5.5	—
France	5.6	1.6
Germany	1.5	0.75
Iceland	4.0	1.0†
Italy	4.0	1.25
Japan	8.0	1.5
Norway	7.5	1.25
Russia	20.0	1.0
Spain	5.0	0.88
Sweden	6.2	1.2
Switzerland ...	4.0	1.4
United States of America ...	28.0	9.8

Adopting these figures, it appears that the available horse-power of the world is of the order of two hundred millions, of which approximately twenty-five millions is at present developed or is in course of development.

Power Available in Great Britain and in the British Empire.—With the noteworthy exceptions of Canada and New Zealand, practically nothing had been done, prior to 1915, by any part of the British Empire, to develop or even systematically to investigate the possibilities of developing its water powers. It is true that a number of large installations had been constructed in India and Tasmania, but their aggregate output was relatively inconsiderable.

* Including projected extensions to plants now in operation.

† Projected, but not yet constructed.

Since then, however, there has been a general tendency to initiate such investigations, and at the present time these are being carried out with varying degrees of thoroughness in India, Ceylon, Australia, South and East Africa, and British Guiana. While it is known that there is ample water power in Newfoundland, Nigeria, Rhodesia, Papua, and the Gold Coast, no very definite information is available, nor are any steps apparently being taken to obtain data in these countries.

The Water-power Committee of the Conjoint Board of Scientific Societies, which has been studying the state of investigation and development throughout the Empire since 1917, has, however, come to the conclusion that its total available water power resources are at least equivalent to between 50 and 70 million horse-power.

Of the developed power in the Empire about 80 per cent. is in Canada. Throughout the remainder of its territories only about 700,000 horse-power is as yet developed, or only a little over 1 per cent. of the power available, a figure which compares with about 24 per cent. for the whole of Europe, and 21 per cent. for North America, including Canada and the U.S.A. These figures sufficiently indicate the relatively large scope for future development.

Power Available in Great Britain.—With a view of ascertaining the resources of our own islands, a Board of Trade Water Power Resources Committee was appointed in 1918. This Committee, which has just presented its final report, has carried out preliminary surveys of as many of the more promising sites as its limited funds allowed, and has obtained data from the Board of Agriculture for Scotland, the Ordnance Survey Department, the Ministry of Munitions, and from civil engineers in private practice, regarding a large number of other sites.

As might be anticipated, Scotland, with its comparatively high rainfall, mountainous area, and natural lochs, possesses relatively greater possibilities than the remainder of the United Kingdom, and investigation has shown that it offers a number of comparatively large schemes. Nine of the more immediately promising of those examined by the Committee have an average output ranging from 7,000 to 40,000 continuous 24-hour horse-power, and an aggregate capacity of 183,000 horse-power, while in every case the estimated cost of construction is such that power could be developed at a cost appreciably less than from a coal-fired station built and operated under present-day conditions. The aggregate output of the Scottish schemes brought before the notice of the Committee, some of which, however, are not commercially feasible at the moment, is roughly 270,000 continuous horse-power.

In addition to these there are a very large number of other small schemes which have not yet been investigated,* and it is probably well within the mark to say that there are water-power sites in the country capable of developing the equivalent of 400,000 continuous horse-power, or 1,500,000 horse-power over a normal working week, at least as cheaply as from a coal-fired installation.

A number of attractive schemes are also available in North Wales, though these are in general more expensive than those in Scotland.

Owing to the general flatness of the gradients, there are, except possibly around Dartmoor, no schemes of any large individual magnitude in England, but there are a large number of powers ranging from 100 to 1,000 horse-power which might be developed from river flow uncontrolled by storage.

Investigations on a few typical watersheds throughout England and Wales appear to show that the possible output averages approximately eight continuous horse-power per square mile of catchment area, which would be equivalent to an aggregate of about 450,000 horse-power. Although much of this potential output is not commercially feasible, it would give the equivalent of 500,000 horse-power over a normal working week if only 30 per cent. of it were fully utilised.

In the report recently issued by the Irish Sub-Committee of the Board of Trade Water Power Committee, it is estimated that approximately 500,000 continuous 24-hour horse-power is commercially available in Ireland, and that if utilised over a 48-hour working week, its capacity would be at least seven times as great as that of the engine power at present installed in the country for industrial purposes.

It appears then that, although the water power possibilities of the United Kingdom are small in comparison with those of some more favoured countries, they are by no means so negligible as is commonly supposed, even in comparison with the present industrial steam power resources of the country.

The capacity of the fuel power plants installed for industrial and public utility services in the United Kingdom in 1907 was approximately 9.8 million horse-power. Allowing for an increase of 15 per cent. since then, and an average load factor of 35 per cent., this is equivalent to 32,000 million horse-power hours per annum, or to a continuous 24-hour output of only 3.7 million horse-power.

According to Sir Dugald Clerk, the average consumption of coal per horse-power hour in this country is about 3.9 lb., which, on the above basis, would involve a total annual consumption of 55 million tons for industrial purposes, not including railways or steamships. This figure is in substantial agreement with the

* In a paper read before the Royal Society of Arts on January 25, 1918, Mr. Newlands, M.I.C.E., gave a list of 122 potential Scottish schemes, the capacity of which he estimated, on a very conservative basis, at 375,000 horse-power.

estimate of 60 million tons made for factory consumption in 1913 by the Coal Conservation Committee of the Ministry of Reconstruction, since this latter figure also includes coal used for heating and other manufacturing processes in factories.

Adopting this figure of 32,000 million horse-power hours as the annual demand for power for industrial purposes, it appears that the inland water power resources of the United Kingdom are capable of supplying about 27 per cent. of this, a proportion which, in such an industrial country as our own, is somewhat surprisingly large.

Many of the small powers would be well adapted for linking up, as automatic or semi-automatic stations, into a general network of electricity supply, or for augmenting the output of municipal supply works, as has been done so successfully, for example, at Chester, Worcester, and Salisbury.

The development of the many small schemes available in the Scottish Highlands would probably have a great effect on the social life of the community. It would go far towards reviving and extending those small local industries which should form an essential feature of the ideal rural township. Commercially such undertakings may appear to be of small importance, but as a factor in promoting the welfare of the State, economical and political, their influence can hardly be over-estimated.

Some of the larger schemes in Scotland would lend themselves admirably to transmission to its industrial districts, while others, in close vicinity to the sea-board, would appear to be well adapted for supplying chemical, or electro-physical, or metallurgical processes.

There is a probability that at least two of these schemes will be developed in the near future. One of these—the Lochaber scheme—is capable of developing some 72,000 continuous horse-power, which is to be utilised largely in the manufacture of aluminium. It is interesting to note that when this scheme is completed the British Aluminium Corporation will have, with their station at Kinlochleven, an average continuous output of over 100,000 horse-power, and a maximum capacity of almost 140,000 horse-power.

The second—the scheme of the Grampian Power Company—is intended ultimately to develop upwards of 40,000 continuous horse-power, which it is proposed to use largely for general industrial purposes.

Should this latter scheme be carried to a successful conclusion it is likely to give an impetus to large-scale water power development in Scotland. Its successful operation would certainly lead to the development of others of the same type, which would help to provide a much needed home training ground for British hydro-electric engineers.

While this is admittedly an inopportune moment to suggest anything in the nature of State co-operation in such developments, it may be pointed out that many of the Scottish powers in particular occur in sparsely populated districts, and that, although they would ultimately become remunerative, the difficulty of raising the capital necessary for their development is great. In view of their direct and indirect advantage to the community, it would appear not unreasonable to advocate that financial assistance should be granted by the State in the earlier stages of such developments. If such assistance, say, in the form of a loan maturing after a period of ten or fifteen years, could be granted, it would certainly give an immediate impetus to the development of water power in this country.

* * * *

Uses of Hydro-Electric Energy.—While a large proportion of the energy developed from water power is utilised for industrial purposes and for lighting, power, and traction, an increasing proportion is being used for electro-chemical and electro-metallurgical processes. It is probable, indeed, that we are only on the threshold of developments in electro-chemistry, and that the future demand for energy for such processes will be extremely large.

In Norway the electro-chemical industry absorbed 770,000 horse-power in 1918, or approximately 75 per cent. of the total output, as compared with 1,500 horse-power in 1910. Of this, some 400,000 horse-power was utilised in nitrogen fixation alone.

The production of electric steel in the U.S.A. increased from 13,700 tons in 1909 to 24,000 tons in 1914, and to 511,000 tons in 1918, this latter quantity absorbing 300 million k.w. hours, equivalent to almost 400,000 continuous horse-power.

In Canada, in 1918, the pulp and paper industry absorbed 450,000 horse-power, or 20 per cent. of the total, while the output of central electric stations amounted to 70 per cent. of the total.

The electrification, on a large scale, of trunk line railways is also a probability in the not distant future. In the U.S.A. 650 miles of the main line of the Chicago, Milwaukee, and St. Paul Railway, comprising 850 miles of track, have been electrified, the power for operation being obtained from hydro-electric stations. In France much of the track of the Compagnie du Midi in the region of the Pyrenees has been electrified with the aid of water power; much of the Swiss railway system has been electrified; and the electrification of many other trunk lines on the European continent is at present under consideration.

Quite apart from the probable huge demand in the distant future for energy for the manufacture of artificial fertilisers by some system of nitrogen fixation, agriculture would appear

to offer a promising field for the use of hydro-electric power.

Much energy is now being utilised in the U.S.A. for purely agricultural purposes. In California, for example, there is in effect one vast system of electrical supply extending over a distance of 800 miles with 7,200 miles of high-tension transmission lines. This is fed from seventy-five hydro-electric stations, inter-connected with forty-seven steam plants, to give a total output of 785,000 horse-power. A further group of thirteen hydro-electric schemes now under construction will add another 520,000 horse-power. A large proportion of this power is used in agriculture, and a census in 1915 showed that electric motors equivalent to over 190,000 horse-power were installed on Californian farms. The Californian rice industry is almost wholly dependent on irrigation made possible by electric pumping, while most of the mechanical processes involved in farming are being performed by electric power.

There can be little doubt that the economic development of many of our tropical dependencies is bound up in the development of their water power resources. Not only would this enable railroads to be operated, irrigation schemes to be developed, and mineral deposits to be mined and worked, but it would go far to solve the black labour problem, which promises to be one of some difficulty in the near future.

While those outlets for electrical energy which are now in sight promise to absorb all the energy which can be cheaply developed for many years to come, there are many other probable directions in which cheap energy would find a new and profitable outlet. Among these may be mentioned the purification of municipal water supplies; the sterilisation of sewage; the dehydration of food products; and the preservation of timber.

Scope for Future Water Power Development.—The figures already quoted indicate that the scope for inland water power development throughout the world, and more particularly throughout the British Empire, is likely to be large for many years to come, and it is gratifying to know that British engineers are prepared to play a large part in such development work.

The utilisation of this water power is likely to give rise to some economic problems of interest and importance. When industrial conditions have again become stabilised, the competitive ability of the various nations will depend largely on economy in the application of energy to production and transportation, and the possession of cheap water power is likely largely to counterbalance the possession of such resources as coal and iron as a measure of the industrial capacity of a nation.

While it is probably true in industrial communities that the most attractive water power schemes have already received attention, many of those available in countries which have hitherto been non-industrial are capable of extremely cheap development and will certainly be utilised as soon as a market for their output can be assured.

It is in such countries that the result of these developments is likely to be most marked, and will require most careful consideration. Thus the hydro-electric survey of India now being carried out by the Indian Government indicates that very large water power resources are available in the country, and that, although a few large schemes have been or are being developed, the resources of the country are practically untouched. There can be little doubt that in the course of time a large amount of cheap energy will be available in India for use in industrial processes, and as the country possesses a large and prolific population readily trained to mechanical and industrial processes, along with ample supplies of raw material for many such processes, all the conditions would appear to be favourable for its entry into the rank of manufacturing and industrial nations.

* * * *

Tidal Power.—The question of tidal power has received much attention during the last few years. In this country it has been considered by the Water Power Resources Committee of the Board of Trade, who have issued a special tidal power report dealing more particularly with a suggested scheme on the Severn. The outline of a specific scheme on the same estuary was published by the Ministry of Transport towards the end of 1920.

In France a special commission has been appointed by the Ministry of Public Works to consider the development of tidal power, and it has been decided to erect a 3,000 k.w. experimental plant on the coast of Brittany. With the view of encouraging research, the Government proposes to grant concessions, where required, for the laying down of additional installations.

The tidal rise and fall around our coasts represents an enormous amount of energy, as may be exemplified by the fact that the power obtainable from the suggested Severn installation alone, for a period of eight hours daily throughout the year, would be of the order of 450,000 horse-power.

Many suggestions for utilising the tides by the use of current motors, float-operated air compressors, and the like have been made, but the only practicable means of utilising tidal energy on any large scale would appear to involve the provision of one or more dams, impounding the water in tidal basins, and the use of the impounded water to drive turbines.

The energy thus rendered available is, however, intermittent; the average working head is low and varies daily within very wide limits, while the maximum daily output varies widely as between spring and neap tides.

If some electro-chemical or electro-physical process were available, capable of utilising an intermittent energy supply subject to variations of this kind, the value of tidal power would be greatly increased. At the moment, however, no such process is commercially available, and in order to utilise any isolated tidal scheme for normal industrial application it is necessary to provide means for converting the variable output into a continuous supply constant throughout the normal working period.

Various schemes have been suggested for obtaining a continuous output by the co-ordinated operation of two or more tidal basins separated from each other and from the sea by dams with appropriate sluice gates. This method, however, can only get over the difficulty of equalising the outputs of spring and neap tides if it be arranged that the maximum rate of output is that governed by the working head at the lowest neap tide, in which case only a small fraction of the available energy is utilised.

When a single tidal basin is used it is necessary to provide some storage system to absorb a portion of the energy during the daily and fortnightly periods of maximum output, and for this purpose the most promising method at the moment appears to involve the use of an auxiliary high level reservoir into which water is pumped when excess energy is available, to be used to drive secondary turbines as required. It is, however, possible that better methods may be devised. Storage by the use of electrically heated boilers has been suggested, and the whole field of storage is one which would probably well repay investigation.

If a sufficiently extensive electrical network were available, linking up a number of large steam and inland water power stations, a tidal power scheme might readily be connected into such a network without any storage being necessary, and this would appear to be a possibility which should not be overlooked in the case of our own country.

Investigation Necessary.—A tidal power project on any large scale involves a number of special problems for the satisfactory solution of which our present data are inadequate.

Thus the effect of a barrage on the silting of a large estuary, and the exact effect on the level in the estuary and in the tidal basin at any given time can only be determined by experiment, either on a small installation, or preferably on a model of the large scheme.

Many of the hydraulic, mechanical, and electrical problems involved are comparatively new, and there is little practical experience to serve as a basis of their solution.

Among these may be mentioned :—

1. The most advantageous cycle of operations as regards working periods, mean head, and variations of head.
2. The methods of control and of sluice gate operation.
3. Effect of changes of level due to wind or waves.
4. The best form of turbine and setting and the most economical turbine capacity.
5. The possibilities of undue corrosion of turbine parts in salt water.
6. The best method of operation ; constant or variable speed.
7. Whether the generators shall be geared or direct driven.
8. Whether generation shall be by direct or alternating current.

The questions of interference with navigation and with fisheries ; of utilising the dam for rail or road transport across the estuary ; and, above all, economic questions connected with the cost of production, and the disposal of the output of such an installation, also require the most careful consideration before a scheme of any magnitude can be embarked upon with assurance of success.

In view of the magnitude of the interests involved, and of the fact that rough preliminary estimates indicate that to-day current even for an ordinary industrial load could be supplied from such an installation at a price lower than from a steam generating station giving the same output with coal at its present price, it would appear desirable that these problems should receive adequate investigation at an early date.

NOTES ON BOOKS.

AGGREGATION AND FLOW OF SOLIDS. By Sir George Beilby, F.R.S. London : Macmillan & Co. 1921. 20*s.* net.

This remarkable work, which summarises and supplements twenty years of research by Sir George Beilby, will not only appeal to the student and laboratory worker, but should charm and delight every artificer or person who constructs with solids ; as, if opened anywhere, the book will give some hint or sentiment of a new or unexpected property incidental to the solid state, all being told in so pleasant and intelligible a fashion that an ordinary village carpenter or an average blacksmith's apprentice may understand an item or idea without breaking the sense of sequence of a first scan over ; the basic idea being always expressed concisely, clearly and unmistakably. The reader will soon find side issues of interest, a state of things giving admirable incentive to further study. For example, our casual reader may glance at page 45 and learn that iron and gold wires twisted together and heated in ammonia gas to a temperature far below fusion will intermingle, partially weld or flow together, the gold sometimes forming a compact coating on the iron.

In his further study, our casual reader may pass on to the various semi-fluid or *quasi* fluid aspects of gold below the melting point, to the general behaviour of hot metals in ammonia

gas; the theory of polishing, and especially the difficult case of calcite or Iceland spar (p. 100); and maybe he will about this time interest himself in the notable speculations and determinations of Professor Bragg as to the structure and magnitude of the calcite molecule, at which stage he will be fairly on the way to study the whole of the book.

Sir George, in his preface, refers to the pleasantness of the experimental work now recorded; but he candidly admits that the preparation for publication was by no means so agreeable as the experimental work, and that, but for help rendered to him by Sir Herbert Jackson and Mr. W. D. Haigh, the work of preparing for publication could not have been accomplished.

The volume comprises xvi + 256 large octavo pages of text and 34 full-page plates or groupings of subjects with explanatory insets; the plates being mostly photomicrographs of exceptional technical excellence. Microscopic observations of great delicacy being involved in nearly all the arguments put forward, the first chapter is appropriately devoted to special microscopic methods and measurements.

Plate I., with Section I. of the text, may be taken as a brief guide to the higher study of microscopic measurements and of certain methods which are involved in the author's researches. In the case of Plate I. a scale on one edge actually shows centimetres and millimetres, but for gauging the magnitudes indicated on the chart, each millimetre of the scale stands for 10 micro-millimetres: thus the magnitudes are shown as magnified 100,000 times. The magnitudes thus relatively indicated in convenient proximity are those which bear very directly on the subject matter of the book, and which the reader may with advantage have before him in approximate visual relationship. The text of Section I. not only explains Plate I., but gives particulars of some other magnitudes as far as present-day knowledge allows conjectures or certainties; as, for example, "Distance between centre of calcium atom and CO_3," and the thickness at which the action of a silver plate alters in relation to phase of reflected light. The practical or manipulatory aspect of Section I. treats of special microscopic matters in relation to the subject as vertical illumination by a beam cast downwards through the objective, oblique illumination with its indirect bearing on the resolving power which is available, and its use as a test for polish. Illustrative examples showing the use of vertical and oblique illumination are given by Figs. 5 and 6; a cross drawn with a burnisher on frosted silver, showing as white on a black ground by vertical illumination, but by oblique illumination the cross is black and the ground white.

Being now in possession of the preliminary technics, the reader passes on easily to the experimental results and conclusions. To make all smooth and easy, the subject of surface tension forms in solids is introduced by a few notes and studies of surface tension in the case of fluids; and perhaps we may venture to suggest to the reader that should he wish to study further surface tensions of liquids, he may advantageously refer to pages 279 to 294 of Clerk Maxwell's Theory of Heat, 1885 edition, where theory and application are charmingly interwoven; as even the removal of grease spots is elucidated, and *inter multa alia* we have comments on the tears of strong wine in special reference to Proverbs xxiii. 31, where mention is made to a quality of wine which "moveth itself aright."

Now as to surface tension in solids. Films of gold, silver and platinum, ranging in thickness from a few millionths of a millimetre upwards and firmly adherent to glass or talc were warmed to a temperature of 250° to 400° C., a heat far below the melting point of the most fusible of these metals. At the low temperature mentioned, the thin metallic films acquired a partial molecular mobility analagous to that of an oil film on water, and microscopic examination showed very plainly that surface tension had been at work, this being illustrated by numerous photomicrographs. Evidence of a state of movement under surface tension is afforded by the film being drawn into denser island areas more or less comparable to drops, and secondary effects are noted. Many remarkable properties of gold are studied in detail: physical conditions and the small tendency of gold towards chemical reaction making gold a convenient leading study. Thus in Section IV. we have a study of the magnitude of gold particles which adhere to a glass surface as by molecular cohesion, while in Section VII. the conditions of flow in wire drawing are investigated and data are included as to the point at which over-drawing (by neglect to anneal) sets in. Texture in wire, whether transverse or longitudinal, is depicted in many photomicrographs and its relations to strength and stability are investigated. In one experiment on drawing, half of the draw was at the ordinary temperature and half with the draw plate and wire cooled to —80° C. by immersion in a mixture of solid carbonic acid and ether. Section X. treats of Faraday's work and conclusions: his views as to the real transparency and optical continuity of thin gold being supplemented and confirmed, but Faraday's conjectures as to the relation of the size of the particles in gold-red glass to colour, were not confirmed.

So far the researches of Sir George appear to cast much light on the two characteristic fluencies of the metals when solid: the cruder flow under the hammer or by other mechanical stress, and the higher fluency of inter-penetration in its various aspects.

A quite ancient sentiment as to a hypergaseous or etherial condition of matter seems to shine dimly through the classic researches of Beilby as recorded in the remarkable volume before us, and in the spirit of such casual studies as frequently precede the more profound knowledge of things we may perhaps venture to refer to the September, 1921, issue of the Journal of the Chemical Society (ii., p. 551), where there is a record of Weiss and Lafitte having found an appreciable infusion of zinc or tin into copper during one month at the boiling point of water. Again, in Miller's Elements of Chemistry, Part II., edition 1878, on p. 335, mention is made of a beam which had been a fixture over a copper smelting furnace, the whole beam containing minute beads of metallic copper in its texture, and it is stated that gold has been known to permeate similarly the beams of refineries. Established facts of this character may recall the ancient view that ether is disengaged by all substances (Pythagoras) and the subsequent view (Empedocles, pupil of Pythagoras) that ether not only fills all space, but contains in itself all the materials of the universe; while Plato distinguishes rather definitely between the gross air which we breathe and the ether in which the celestial bodies revolve. There are many quotations and references in the notable work of Dutens, and the imaginary or burlesque conversation between Strepsiades and Socrates in the Clouds of Aristophanes, casts an interesting light on some of the ancient views as to ether, and as to vortices of ether being regarded as the primary creative force.

A book of the century, like Beilby's, which in respect to its mass of notable facts and brilliant deductions, should, in time, take rank with Darwin's Voyage of the Beagle, or Faraday's Lectures on a Candle, requires a good index. May we hope it will be provided for inset? Also a low priced abstract comparable to Maclaurin's Account of Newton's Work would be of use at the present time.

SOIL CONDITIONS AND PLANT GROWTH. By EDWARD J. RUSSELL. Fourth edition. London: Longmans Green and Co., 1921. 16s. net.

Although a fourth edition, it is convenient to regard the present work as a new volume in sequence to the papers and memoirs issued by Rothamsted during more than half a century; also as the first of a new series of monographs on the fundamentals of agriculture; three more of the new series being announced by Messrs. Longmans as in preparation.

Dr. Russell, the author of the present volume, and editor of the series in preparation, is the Director of the Rothamsted experimental station and a leading authority whose reputation will gain in lustre by reason of the well knit and thorough volume now before us.

Commencing with a summary of the literature of his subject from Pietro Crescenzi, a contemporary of Roger Bacon, who collected the Roman writings on agriculture, Dr. Russell leads on, step by step, to the present time. We may pause at the names of Bernard Palissy and John Mayow, the former better known to the general reader as a brilliant and erratic potter than as a chemist; the latter being remembered by many chemists as the discoverer of oxygen (nitro-aerial spirit), and its chief relations to fire and life. To Mayow we also owe the pneumatic trough.

The main text of the book under notice deals comprehensively with bacterial, radio-active, thermic, chemical and physical conditions as bearing on the efficiency of the soil, the abundant detail being made readily available by the help of a good index. The final chapter, "Soil analysis and Interpretation," deserves special mention as being admirably proportioned and arranged.

Conditions affecting soil exhaustion and restoration run like a thread all through the book, and with abundant warnings—tabular, verbal and graphic—against any application of the dangerous and false principle that, "If a little is good, much must be better." In this aspect, the matter on pp. 237-238 is instructive with respect to the peculiar elusiveness of the problem how to determine the best concentration. The curves, particulars and generalisations on pages 40, 41 and 42 are also of special interest.

In summarising, this volume of x + 406 closely printed pages, with good index (in two sections, name and subject), many illustrations, tabular matter, historical introduction and selected bibliography, forms a first class manual for the worker, alike a credit to the eminent author and the publishers.

OBITUARY.

THE EARL OF DUCIE, P.C., G.C.V.O., F.R.S.—The death of the Earl of Ducie, which took place on October 28th, at his seat, Tortworth Court, Gloucestershire, at the age of 94, has deprived the Royal Society of Arts of its oldest Fellow. He was elected in 1857; in 1860 he became a Member of the Council and a Vice-President of the Society, and he took the chair at several of the Ordinary Meetings.

Lord Ducie was born in 1827. In 1852 he entered the House of Commons as Liberal representative for the Borough of Stroud, but in the following year he succeeded his father in the peerage, and went to the House of Lords, of which he became the "Father."

Lord Ducie was Captain of the Yeomen of the Guard from 1859 to 1866, and Lord Warden of the Stanneries from 1888 to 1908. He was created G.C.V.O. in 1906. In 1857 Lord Palmerston appointed him Lord Lieutenant of Gloucestershire and of the cities of Gloucester

and Bristol. He held these offices until his retirement in 1911, at which time he was the oldest Lord Lieutenant living. For over forty years he was Honorary Colonel of the 5th Battalion of the Gloucestershire Regiment. Throughout his life he took a deep interest in military matters. He was a fine shot: nearly 60 years ago he was a member of the English Eight, and for some years he was President of the National Rifle Association.

When the first Council of Clifton College was appointed in 1860 Lord Ducie was elected President, and his tenure of office thus covers the whole period of the School's existence.

Lord Ducie took a deep interest in science, and in 1855 was elected a Fellow of the Royal Society.

JOHN HOWARD GWYTHER.—Mr. John Howard Gwyther, formerly Chairman of the Chartered Bank of India, Australia and China, died in London on October 21st, at the age of 86. As a young man he served on the Far Eastern staff of that Bank, first as accountant at Singapore, and then as manager of the Shanghai Branch. He re-entered the service of the Bank in 1865, as sub-manager in London, and in 1870 was promoted to the chief managership. He filled this post for twenty years, when he became managing director. During his management the reserve fund of the Bank rose from £10,000 to £250,000. In 1893 his friends presented him with his portrait by A. S. Cope. A keen bi-metallist, he took an active part in the work of the old Bimetallic League. He joined the Royal Society of Arts as far back as 1871.

GENERAL NOTE.

UTILISATION OF WASTE TIMBER AND COTTON STALKS.—An enormous amount of wood is wasted in the process of converting the felled tree into merchantable timber. It has been estimated that in the United States alone, the quantity of wood waste produced annually in the saw-mill amounts to 4,000 million cubic feet. Much of the wood at present wasted could be utilised for such purposes as the manufacture of paper pulp, and the production of turpentine, acetic acid, and other products. The question has recently received consideration in New Zealand, and it has been suggested that the waste, in some instances, might be used for paper-making in place of imported wood-pulp. In order to ascertain the suitability of certain New Zealand timbers for this purpose, an investigation has been conducted at the Imperial Institute, the results of which are recorded in the current number of its quarterly *Bulletin*. It was found that the timbers examined could all be used for the manufacture of paper pulp, but whether such an industry would be profitable in New Zealand would depend on purely economic factors, such as the quantity of waste wood available, its cost at the pulp-mill and the price of fuel and chemicals, etc. Another article in the same *Bulletin* deals with the problem of the commercial utilisation in cotton growing countries of the vast quantities of cotton stalks which are produced each year and have to be removed from the fields after the cotton crop has been gathered. Investigation at the Imperial Institute has shown that the stalks form a promising material for paper-making and that they might also be used for obtaining acetic acid, tar and charcoal by a process of dry distillation.

MEETINGS OF THE SOCEITY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock (unless otherwise announced).

NOVEMBER 9.—D. R. WILSON, M.A., Secretary of the Industrial Fatigue Research Board, "The Work of the Industrial Fatigue Research Board and its Applications to Industry." WILLIAM GRAHAM, LL.B., M.P., Chairman I.F.R.B., and Member of the Medical Research Council, will preside.

NOVEMBER 16 (4.30 p.m.).—T. H. LYON, M.A., Director of Design in the University School of Architecture, Cambridge, "Modern Buildings in Cambridge and their Architecture." BASIL OLIVER, F.R.I.B.A., will preside.

NOVEMBER 23.— PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S., Albert Medallist, "The Coming of Age of Long-Distance Wireless Telegraphy and some of its Scientific Problems" ("Trueman Wood" Lecture). ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council will preside.

NOVEMBER 30.—NOEL HEATON, B.Sc., "The Preservation of Stone." SIR FRANK BAINES, C.B.E., M.V.O., Director of Works, H.M. Office of Works and Public Buildings, will preside.

DECEMBER 7.—EMIL CAMMAERTS, "Literature and International Relations." H.E. the Belgian Ambassador will preside.

DECEMBER 14.—SIR WALTER BEAUPRE TOWNLEY, K.C.M.G., Minister to the Netherlands, 1917-19, "Trade with the Netherlands East Indies." THE RIGHT HON. LORD EMMOTT, G.C.M.G., G.B.E., will preside.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(Joint Meeting.)

At 4.0 p.m.

FRIDAY, NOVEMBER 25.—A. H. ASHBOLT, Agent-General for Tasmania, "An

Imperial Airship Service." BRIG.-GENERAL LORD MONTAGU OF BEAULIEU, K.C.I.E., C.S.I., will preside.

DOMINIONS AND COLONIES SECTION.

At. 4.30 p.m.

TUESDAY, DECEMBER 6.—FREDERICK COATE WADE, B.A., K.C., Agent-General for British Columbia, "British Columbia—The Awakening of the Pacific."

Papers to be read after Christmas:—

LAWRENCE HAWARD, M.A., Curator of the City Art Gallery, Manchester, "The Manchester Art Gallery and the Problem of Provincial Collections."

HOWARD MAURICE EDMUNDS, "Photo Sculpture."

CLOUDESLEY BRERETON, M.A., Divisional Inspector to the London County Council (Modern Languages), "Some Thoughts on Diction, and the Need of a National Conservatoire."

JOHN FRANCIS CROWLEY. D.Sc., B.A., M.I.E.E., "Electrical Driving in the Jute Industry."

W. A. APPLETON, C.B.E., Secretary to the General Federation of Trade Unions, "Economics and Labour."

WILLIAM REGINALD ORMANDY, D.Sc., F.C.S.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "Some Solved and Unsolved Problems in Gas Works Chemistry."

ALEXANDER SCOTT, Sc.D., D.Sc., M.A., F.R.S., "The Restoration and Preservation of Objects at the British Museum."

ARTHUR WILCOCK, "Surface Printing by Rollers in the Cotton Industry."

GEORGE FLETCHER, Department of Agriculture and Technical Instruction for Ireland, "The Natural Power Resources of Ireland."

J. H. HUXLEY, "The Control of Sex in Animals."

ALEXANDER L. HOWARD, "The Timbers of India and Burma." (Indian Section.)

PROFESSOR WILLIAM ARTHUR BONE, D.Sc., Ph.D., F.R.S., "Brown Coals and Lignites: Their Importance to the Empire." (Joint Meeting Dominions and Indian Sections.)

PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., "The Indigo Situation in India." (Indian Section).

F. G. ROYAL DAWSON, M.Inst.C.E., Chief Engineer to Indian Railway Board, "The Need for an All-Indian Gauge Policy." (Indian Section.) SIR HENRY PARSALL BURT, K.C.I.E., C.B.E., will preside.

PROFESSOR SIR THOMAS W. ARNOLD, C.I.E., Litt.D., M.A., Hon. Fellow of Magdalene College, Cambridge, *Sir George Birdwood Memorial Lecture.* (Indian Section.)

LIEUT.-COLONEL SIR THOMAS BILBE ROBINSON, G.B.E., K.C.M.G., "Queensland." (Dominions and Colonies Section.)

CANTOR LECTURES.

At 8 0 p.m.

MONDAYS.—ARTHUR M. HIND, O.B.E., M.A., Assistant-Keeper, Department of Prints and Drawings, British Museum, and Slade Professor of Fine Art in the University of Oxford, "Processes of Engraving and Etching." Three Lectures.

Syllabus.

LECTURE I.—NOVEMBER 28.—Wood-cut.—The Process and its Origin—The Early Anonymous Woodcutters—Original and Reproduction Work—Wood-cut and Wood-engraving—The great designers for Wood-cut: Dürer, Holbein and others—The special fitness of the Process for Book Illustration—Modern Work and its Scope.

LECTURE II.—DECEMBER 5.—Line-Engraving.—The Process and its Origin—Its Relation to the Work of the Goldsmith—The Great Masters of Original Engraving: Dürer, Marcantonio and others — Reproductive Engraving — Technical character of work in reference to the various aims of the Art.

LECTURE III.—DECEMBER 12.—Etching.—The Process and its Origin—Survey of work by the great original Etchers: Rembrandt, Van Dyck and others—Examination of the special qualities of Etching in relation to different kinds of work—Recent Etching.

C. AINSWORTH MITCHELL, M.A., F.I.C., "Inks." Three Lectures.

Syllabus.

LECTURE I.—JANUARY 23.—Historical Introduction—Nature of Inks—Egyptian and Chinese Inks—Modern Carbon Inks—Sepia—Iron Gall Writing Inks—Methods of Preparation—Properties—Iron Tannates.

LECTURE II.—JANUARY 30.—Logwood Inks—Vanadium Inks — Aniline Inks —.Coloured Writing Inks—Examination of Writing Inks—Characteristics of Ink in Writing—Copying Inks.

LECTURE III.—FEBRUARY 6.—Marking Inks—Printing Inks—Preparation of Lamp Black—Carbon Blacks—Boiled Oils—Typing Ink—Inks for Miscellaneous Purposes—Secret Writing.

ALAN F. C. POLLARD, F.Inst.P., A.M.I.E.E., late Professor of Optical Engineering and Instrument Design, Imperial College of Science and Technology, South Kensington. "The Mechanical Design of Scientific Instruments." Three Lectures.

Syllabus.

LECTURE I.—FEBRUARY 20.—Design from the point of view of the User and the Manufacturer—Clerk Maxwell's axioms of Instrument Design—Degrees of Freedom and Constraint—The Six Degrees of Freedom of a Rigid Body—Geometric Design.

LECTURE II.—FEBRUARY 27.—The Lower and Higher Pairs—Restraint against Sliding—Restraint against Rotation—Centrodes and Axodes—The Design of Profiles.

LECTURE III.—MARCH 6.—The Elastic Nature of all Materials—The Elastic Constants—The Rigidity of Instruments—Manufacture—Models—Interchangeable Manufacture.

GUY RADCLIFFE, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester, "The Constitutents of Essential Oils." Three Lectures. March 20, 27, April 3.

COBB LECTURES.

At 8.0 p.m.

MONDAYS, F. F. RENWICK, F.I.C., F.C.S., A.C.G.I., "Modern Aspects of Photography." Three Lectures. May 1, 8, 15.

MANN JUVENILE LECTURES.

At 3.0 p.m.

THURSDAYS, JANUARY 4 and 11, 1922.

MEETINGS OF SOCIETIES FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 7..Royal Institution, Albemarle Street, W., 5 p.m. General Monthly Meeting.
Engineers, Society of, at the Geological Society, Burlington House, W., 5.30 p.m. Mr. C. H. Naylor, "Extraction Turbines."
Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, W., 8 p.m., Mr. N. E. Rambush, "Comparison between Laboratory Fuel Tests and Practical Working Results of the Producer Gas Process."
Geographical Society, 135, New Bond Street, W., 8.30 p.m.
British Architects, Royal Institute of, 9, Conduit Street, W., 8.30 p.m. President's Opening Address.
Electrical Engineers, Institution of, Victoria Embankment, W.C., 7 p.m. (Informal Meeting.) Mr. J. S. Highfield, "How best to Speed up Electrical Progress." (Western Centre), at the South Wales Institution of Engineers, Cardiff, 6.30 p.m. Address by Chairman, Mr. A. C. McWhirter.

TUESDAY, NOVEMBER 8..Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m.
Electrical Engineers, Institution of (Scottish Centre), 207, Bath Street, Glasgow, 7.30 p.m. Address by Chairman, Mr. E. T. Goslin.
British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.15 p.m. Mr. W. G. Raffé, "The Psychology of Light and Colour in Relation to Design."
Zoological Society, Regent's Park, N.W., 5.30 p.m. (1) Mr. Edgar P. Chance, "The Laying-habits of the Cuckoo (*Cuculus canorus*) and the Life of the Young Cuckoo." (2) Dr. W Rae Sherriffs, "Evolution within the Genus.—Part I. *Dendronephthya* (*Spongodes*), with Descriptions of a Number of Species. Part II. Description of Species (Alcyonaria) taken by the 'Siboga' Expedition." (3) Dr. Chas. F. Sonntag, "The Comparative Anatomy of the Tongues of the Mammalia.—V. Lemuroidea and Tarsioidea. VI. Summary and Classification of the Tongues of the Primates." (4) Mr. R. I. Pocock, "The External Characters and Classification of the Mustelidæ."

WEDNESDAY, NOVEMBER 9..ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Mr. D. R. Wilson, "The Work of the Industrial Fatigue Research Board and its Applications to Industry."
Geological Society, Burlington House, W., 5.30 p.m.
Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 8. p.m. Dr. L. Aitchison, "Chromium Steels and Irons."
Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. (Wireless Section). Dr. G. W. Howe, "Opening Address."

THURSDAY, NOVEMBER 10..Garden Cities and Town Planning Association, King's College, Strand, W.C., 5.30 p.m. Dr. H. P. Berlage, "Amsterdam—Past and Present."
University of London, at the Imperial College of Science and Technology, South Kensington, S.W., 5.30 p.m. Mr. W. Bateson, "Recent Advances in Genetics." (Lecture II.)
At the School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Mr. L. Binyon, "Japanese Art." (Lecture II.)
Child Study Society, at the Royal Sanitary Institute, 90, Buckingham Palace Road, S.W., 6 p.m. Mr. F. S. Marvin, "The Teaching of History."
Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W., 7.30 p.m. (1) Dr. A. Gleichen, "The Path of Rays in Periscopes having an Inverting System comprising two Separated Lenses." (2) Dr. J. W. French, "The Interocular Distance." (3) Mr. T. Chaundy, "Note on the Thin Astigmatic Lens."
Historical Society, 22, Russell Square, W.C., 5 p.m. Mr. H. G. Rawlinson, "The Embassy of William Harborne to Constantinople, 1578-88."
Mechanical Engineers, Institution of (North-Western Branch), Memorial Hall, Albert Square, Manchester, 7 p.m. Dr. H. S. Hele Shaw, "Power Transmission by Oil."

FRIDAY, NOVEMBER 11..London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. Mr. W. D. Caröe, "Old London Bridge."
Electrical Engineers, Institution of (Irish Centre), Royal College of Science, Dublin, 8 p.m. Discussion on the Report of the Fuel Research Board in the Winning, Preparation and Use of Peat in Ireland, and in the Report of the Sub-Committee on the Water Power Resources of Ireland."
Astronomical Society, Burlington House, 5 p.m.
Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

SATURDAY, NOVEMBER 12..Chromatics, International College of, Caxton Hall, Westminster, S.W., 3.15 p.m. Miss Grace E. Cowell, "Colour in Persian Ceramics."

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FRIDAY, NOVEMBER 11, 1921.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, NOVEMBER 16th, at 4.30 p.m. (Ordinary Meeting.) T. H. LYON, M.A., Director of Design in the University School of Architecture, Cambridge, "Modern Buildings in Cambridge and their Architecture." BASIL OLIVER, F.R.I.B.A., will preside.

Full particulars of the arrangements for the Session, so far as they are at present complete, were published in the last number of the *Journal*.

FIRST ORDINARY MEETING.

WEDNESDAY, NOVEMBER 2nd, 1921; MR. ALAN A. CAMPBELL SWINTON, F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as Fellows of the Society :—

Adam, John, Edinburgh.
Aikins, Sir James Albert Manning, K.C., Winnipeg, Manitoba, Canada.
Ambrose, John Robert William, Toronto, Ontario, Canada.
Arnall, Arthur Thomas, B.Sc., Assoc. M Inst.C.E., London.
Ayyar, R. Panchanadam, Trichinopoly, Deccan, India.
Banerjee, Probodh Chunder, Calcutta, India.
Butler, Matthew Joseph, C.M.G., LL.D., LL.B., M.Inst.C.E., Oakville, Ontario, Canada.
Byramji, Khan Bahadur B.P., Nagpur, Central Provinces, India.
Chettiar, T. N. Muthiah, Trichinopoly, South India.
Clarke, Frederick, Prince George, British Columbia, Canada.
Curling, Bernard Charles, London.
Dare, Invor Colin, Karachi, India.
Day, William Thomas, London.
DeCew, Judson Albert, B.A.Sc., New York City, U.S.A.
Devey, John Hardy, Vancouver, British Columbia, Canada.
Fell, Sir Godfrey Butler Hunter, K.C.I.E., C.S.I., London.
Fournier, Arthur, Quebec, Canada.
Gunnis, Major Arthur Albert, M.A., London
Harvey-Tomeo, William, A.M.I.A.E., London.
Harvie, Eben Nasmyth, Bromsgrove, Worcestershire.
Harvie, William, London.
Haycraft, Hermann Clark, B.Sc., London.
Hesketh, Lieut.-Colonel James Arthur, C.M.G., D.S.O., Winnipeg, Canada.
Hunt, Herbert, Erith, Kent.
Jacobs, Lionel Leslie, F.C.S., A.M.E.I.C., Montreal, Canada.
Jamieson, Edgar Archibald, Vancouver, British Columbia, Canada.
Jeffs, Cameron, Chorley Wood, Herts.
Ketchen, William Laird, Quebec, Canda.
Kotibhaskar, Moreshwar Ganesh, M.Sc.Tech. (Manchester), M.A., B.Sc. (Bombay), Manchester.
Lamontagne, Captain Yves, B.Sc., Montreal, Canada.
Leonard, Lieut.-Colonel Reuben Wells, St. Catherine's, Ontario, Canada.
Lynch, Rev. Frederick, B.D., New York City, U.S.A.
Macdonald, Captain Charles Beverley Robinson (late R.E.), London.
McGregor, Major James, D.S.O., M.Inst.C.E., Glasgow.
Mackenzie, Professor Chalmers J., M.C., B.E. Saskatoon, Canada.
McRae, Captain W. A. R. M., London.
Mohideen, Unes Lebe Ahmed, Hong Kong, China.
Montagu of Beaulieu, Brigadier-General Lord, K.C.I.E., C.S.I., Beaulieu, Brockenhurst, Hants.
Mukerji, G. C., Giridih, India.
Seaman, L. N., M.A., B.Sc., A.M.E.I.C., Dehra Dun, India.
Simmons, Albert William, Clifton, Bristol.
Simmons, Thomas Henry, Clifton, Bristol.
Smith, J. Grove, Ottawa, Canada.
Smith, Robert W., M.I.E.E., Kimberley, South Africa.
Snelling, Captain Cyril Grey, I.A., Quetta, Baluchistan, India.
Takagi, Nobutake, Tokio, Japan.

Teichelmann, Major Ebenezer, N.Z.M.C., F.R.C.S., Hokitika, New Zealand.

Udall, Charles, Nairobi, British East Africa.

Vollmer, Captain George Frederick, M.Sc., St. Catherine's, Ontario, Canada.

Watson, James Allen, Perth.

Winckler, Herbert Mills, Jeypore, Madras, India.

The Chairman's address will be published in the next number of the *Journal*.

INDIAN SECTION.

A meeting of the Indian Section Committee was held on Friday, November 4th.

PRESENT :—Sir Charles S. Bayley, G.C.I.E., K.C.S.I., in the chair ; Sir Charles H. Armstrong, Sir M. M. Bhownaggree, K.C.I.E., Sir George C. Buchanan, K.C.I.E., M.Inst.C.E., Mr. D. T. Chadwick, C.I.E., Sir Frederic W. R. Fryer, K.C.S.I., Colonel Arthur Hills Gleadowe-Newcomen, C.I.E., V.D., Major-General Beresford Lovett, C.B., C.S.I., Dr. J. A. Voelcker, M.A., F.I.C., and Colonel Sir Charles Edward Yate, Bt., C.S.I., C.M.G., M.P., with Mr. G. K. Menzies, M.A. (Secretary of the Society), and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions Sections).

WATER-POWER IN THE BRITISH EMPIRE.

The Water-Power Committee of the Conjoint Board of Scientific Societies has issued a final report, thereby bringing its full and valuable inquiries to a termination. The Committee was appointed four years ago to ascertain the amount and distribution of water-power in the Empire, including the United Kingdom. A preliminary report was presented in July, 1918. This was followed by another report in March, 1919. All interested in this important subject will be glad to learn that it is hoped to publish shortly a combined edition of these three excellent reports.

In the final report, the information received by the Committee since the publication of the second, is summarised.

The water-power resources of the United Kingdom have been investigated by a Board of Trade Committee, which issued its first interim report in 1919. At this stage that Committee had carried out preliminary investigations of nine of the more promising sites in Scotland, of the more hopeful areas in North Wales, of the English Lake District, and of typical English rivers. "By far the greater part of the water-power of the United Kingdom is," it is mentioned, "situated in Scotland, and from the nine sites examined by the Committee, some 183,000 continuous horse-power is available. This is only a fraction of the total water-power in the country, and it would appear probable, that the possible output is well over 1,000,000 horse-power, of which a considerable proportion is commercially feasible."

With regard to India, the second report of the Conjoint Board Committee contained certain recommendations as to training in hydro-electric engineering. The Committee notes with satisfaction that the Government of India have, as a preliminary measure, given instructions for a course of lectures in the major engineering colleges in the control of the Bombay, Madras, Bengal, and U.P. Governments, by an expert in hydro-electric engineering. "The development of Indian water-powers would appear," says the Committee, "to offer a most promising field to British manufacturers, and one in which some initial sacrifice would be amply repaid."

The Committee concludes its review of the present position as regards investigation throughout the Empire, as follows :—"It will be seen that in Great Britain, India, Canada, New Zealand, Tasmania, and some portions of Australia, more or less adequate steps are being taken by the various Governments, and that definite preliminary steps have been taken in the Union of South Africa, in British East Africa, in Ceylon, in British Guiana and in Egypt. In the remaining countries of the Empire, nothing definite is being done, or appears to be projected, although the potential water-power in New Guinea, Burma and West Africa, for example, is known to be very large indeed ; while where investigation work has been initiated, with the exception of Great Britain, Canada, New Zealand, and possibly India, the scope of the work does not appear to be in any way commensurate with the importance of the subject. Taking the Empire as a whole, no attempt is being made to ascertain the total resources, to secure any uniformity in methods of investigation and recording of data, to encourage such investigations as are being made, or to collect the information as it becomes available at a central bureau. At present, not even an approximately complete inventory exists, much less the practical and commercial information that would assist development of this important national resource."

The Committee supplements the facts it has previously given about the more active development in other countries. For instance, it is estimated that Brazil has available at least 26,000,000 h.p., of which some 320,000 h.p. is developed. Iceland's water-power is computed to be at a minimum 4,000,000 h.p., and the Norwegian Iceland Company proposes to erect six power stations capable of generating slightly over 1,000,000 h.p. for seven months of the year, and 700,000 h.p. for the remaining five months. In Japan, the works completed or in progress, total over 1,000,000 h.p. How unfavourably our position in this respect compares with that of our competitors, is shown by the following instructive table :—

—	Hydraulic Horse-Power.		Per cent. of available now developed.
	Available.	Developed.	
Europe: Germany, Italy, Switzerland, Spain, Sweden, Austria-Hungary, France and Norway	47,300,000	8,450,000	18.0
United States	32,000,000	6,500,000	20.3
British Empire	60,000,000	3,000,000	5.0

The Committee again calls attention to the urgent need of an Imperial Water-Power Board, "with extensive powers to carry out a comprehensive policy for stimulating, co-ordinating, and where necessary, assisting such developments throughout the Empire." The headquarters should be in London, the Board to include a representative of each of the Dominions, and Dependencies. Would not the Committee itself form a suitable nucleus for such a board? The Committee also recommends that an Imperial Water-Power Conference be held in the capital of the Empire at an early date.

The report is signed by the Chairman of the Committee, Sir Dugald Clerk, K.B.E., F.R.S., and the Secretary, Professor A. H. Gibson, D.Sc., M.Inst.C.E.

OBITUARY.

Professor Dimitris Tschernoff.—Intimation has been received of the death of Professor Dimitris Tschernoff, which took place at Yalta, in the Crimea, in January last, in his eighty-second year. He was elected an Honorary Corresponding Fellow of the Royal Society of Arts in 1909, and by a rather curious coincidence, some account of his work in metallography was given in the article by Colonel N. Belaiew, C.B., which appeared in the last number of the *Journal*.

Dimitris Tschernoff was born in Petrograd in 1839. He was educated at the Institute of Technology in his native city, and after spending some time as Lecturer in Mathematics at the University of Petrograd, he returned to the Institute of Technology as Assistant Librarian in 1863. In 1866 Oboukoff offered him a post in his steel works.

His most important contribution to the Metallurgy of Steel is considered to be his treatise on critical points in steel, delivered to the Imperial Russian Technical Society in 1868. The manufacture of steel guns had been started in Russia but ten years before. The processes were comparatively new. In other countries Krupp had started manufacturing, but in the utmost secrecy. In Russia, the Zlatoust Plant was the only one in which steel foundry work was carried on, and even there only on a small scale. Under these conditions, every single operation—from the pouring of the liquid metal to the forging, and heat treatment processes—bristled with difficulties. It is easy to understand, therefore, that Messrs. Lavrow and Kalakoutzky's researches on the liquetaction of steel, and on the specific weights, seemed to Tschernoff to warrant the most serious attention, and that he made these researches the object of the most far reaching survey, intending to make the results widely known to all the prominent men connected with technical science and metallurgy. Simultaneously, he resolved to present to the Technical Society his own researches on the structure and properties of steel. These researches, thanks to their newness and their brilliance, at once captured everyone's attention.

The representatives of the scientific and technical world observed at once that there was something more in the paper of the young engineer than a critical survey of an important technical research. They felt that the investigations made on steel castings at a steel plant went deeply into the properties of the matter, and would enable the whole realm of steel practice to be put on a scientific and rational basis. That Professor Tschernoff's researches would serve as a starting point for a whole new branch of physical chemistry — metallography— they were not able to realise; no one was. The paper started violent discussions; the audience would not agree with many of the statements it contained. They would not believe in the possibility of much of what was said, but the keenest interest was aroused.

In 1878 Tschernoff read before the Russian Technical Society an important paper on "The Structure of Cast Steel Ingots," in which he discussed such defects in steel castings as piping, blow-holes, segregation, and so on; simultaneously, he drew such a picture of the crystallisation of a steel ingot that his paper became a classic.

In 1889 Tschernoff was asked by the then director of the Michael Artillery Academy, General Demianenkoff, to join the professional staff of the Academy, and to occupy the chair

of Metallurgy and Metallography of Steel. From that date onwards, he began to acquaint his audience with his researches on steel, and inspired his students with a profound and deep interest in metallography and science in general.

Up to his last days, Professor Tschernoff continued to work very hard in exceedingly difficult surroundings, "without books, without necessary food, and even without warm clothing." But he did not lose heart. He read papers on steel, he lectured in the Technical Institution, and he also worked on some of the mathematical problems which resulted in his paper under the title "The Impossible," on the tri-section of the right angle.

To the very end he continued to be a great lover of music. One of his hobbies was to make violins which would stand comparison with the best Italian ones. His violins were possessed of unusual qualities, and on several occasions when a public test was made, side by side with the best instruments of Amati and Stradivari, they were said to have held their own.

GENERAL NOTES.

TOBACCO GROWING IN VICTORIA.—The cultivation of tobacco in the North-Eastern district of Victoria is being enthusiastically taken up by land owners. A recent report from Wangaratta stated that, given a suitable season, the area will be increased to easily double that of the previous years. Syndicates have been formed at Strathbogie, Kangaroo Flat, Bright, Chiltern and Stawell, to grow tobacco, and, according to the *Industrial Australian*, it is estimated that there will be at least 200 new growers this season. Buyers of tobacco have intimated that they do not intend to drop the prices as compared with the last two seasons, and they have already paid up to 3s. a lb. for flue-cured leaf, and 1s. 9d. a lb. for air-cured for last season's crop. They have also stated that flue-cured leaf will be bought at higher prices in preference to air-cured leaf, the quality suiting them much better. There are possibilities of the air-cured leaf dropping out of the market.

SHIPMENT OF MOTORCARS TO AUSTRALIA FROM GENOA.—We learn from a Turin paper "*La Gazetta del Populo*," that 10 autocars were lately shipped from Genoa to Australia in a single lot by an Italian firm, the "*Scat*". This will probably not be the last.

MEETINGS OF SOCIETIES FOR THE ENSUING WEEK.

MONDAY, NOVEMBER 14 .. Brewing, Institute of (London Section) 30, Russell Square, W.C., 8 p.m. Mr. H. Heron, "Some Notes on the Deterioration of Hops during Storage."

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m. Presidential Address.

Electrical Engineers, Institution of (N. Eastern Section), Armstrong College, Newcastle, 7.15 p.m. Mr. E. S. Byng, "Telephone Line Work in the United States."

TUESDAY, NOVEMBER 15 .. Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m.

Electrical Engineers, Institution of (N. Midland Section), Hotel Metropole, Leeds, 7 p.m. Mr. W. E. Burnand—Chairman's Address. (N. Western Section), 17, Albert Square, Manchester, 7 p.m., Mr. W. Walker—Chairman's Address.

Civil Engineers', Institution of, Great George Street, S.W., 6 p.m. Mr. F. G. Royal-Dawson, "The Indian Railway Gauge Problem."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m.

Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, London, 8 p.m. Reports on "Progress during the Vacation" and "Developments in Gas Lamps and Electric Lamps and Lighting Appliances."

WEDNESDAY, NOVEMBER 16 .. ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 4.30 p.m. Mr. T. H. Lyon, "Modern Buildings in Cambridge, and their Architecture."

Microscopical Society, 20, Hanover Square, W., 8 p.m. 1. Mr. G. Patchin, "The Micro-examination of Metals, with special reference to Silver, Gold and the Platinum Metals." 2. Mr. R. L. Frink, "The Practical Value of the Microscope in Glass Manufacture." 3. Mr. W. C. Crawley and Dr. H. A. Baylis, "Mermis parasitic on Ants of the genus *Lasius*."

United Service Institution, Whitehall, S.W., 2.30 p.m. Brig.-General T. R. V. Bate, "Horse Mobilisation."

Royal Meteorological Society, 49, Cromwell Road, South Kensington, S.W. 7, 5 p.m. 1. Dr. H. Jeffreys, "On the Dynamics of Wind." 2. Mr. N. K. Johnson, "The Behaviour of Pilot Balloons at Great Heights." 3. Mr. C. P. J. Cave, "The Cloud Phenomenon of November 29th, 1920."

THURSDAY, NOVEMBER 17 .. Royal Aeronautical Society, at THE ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Colonel F. Searle, "Requirements and Difficulties of Air Transport."

Royal Society, Burlington House, W., 4.30 p.m.

Mechanical Engineers, Institution of (Midland Branch), The University, Birmingham, 7.30 p.m. Dr. H. S. Hele-Shaw, "Power Transmission by Oil."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Mr. E. S. Byng, "Telephone Line Work in the United States."

University of London, Imperial College of Science, S. Kensington, S.W., 5.30 p.m. Mr. W. Bateson, "Recent Advances in Genetics." (Lecture III.)

At the School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Mr. L. Binyon, "Japanese Art." (Lecture III.)

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, W., 5.30 p.m.

FRIDAY, NOVEMBER 18 .. Transport, Institute of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. J. P. Thomas, "The Operation and Development of Urban Electric Railway Services."

Metals, Institute of, at the Institution of Mechanical Engineers (Sheffield Local Section), Mappin Hall, The University, Sheffield, 7.30 p.m. Prof. C. H. Desch, "The Services of Dr. Sorby to Metallurgy."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Dr. E. H. Salmon, "The Machinery of Floating Docks."

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